TVS-AP-81-118

High Occupancy Vehicle Lanes on Freeways : Current Status in North America and Implications for Ontario

G. Allen
Research Officer
Transport and Vehicle Systems
Research and Development Branch

Published by:
The Policy Planning and Research Division
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

Published without prejudice
as to the application of the findings.
Crown copyright reserved; however, this
document may be reproduced for non-commercial
purposes with attribution to the Ministry.

For additional copies write:
The Editor
Research and Development Branch
Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

June, 1981

CONTENTS

PAGE

LIST OF EXHIBITS iv

EXECUTIVE SUMMARY v

1/ INTRODUCTION 1

2/ THE ROLE OF PREFERENTIAL LANES IN FREEWAY MANAGEMENT 3
2.1/ Traffic Management. 3
2.2/ Increased Vehicle Occupancy 4

3/ CONTRA-FLOW LANES 6

4/ CONCURRENT-FLOW LANES 9

5/ SEPARATE RIGHTS-OF-WAY 13

6/ METERED-RAMP BYPASS LANES 16

7/ ONTARIO FREEWAY CHARACTERISTICS 18
7.1/ Toronto 18
7.2/ Hamilton and Ottawa 20

8/ CONCLUSIONS 22
8.1/ General Conclusions 22
8.2/ Specific Conclusions 23

9/ ADDITIONAL SOURCES 27

CONTENTS

PAGE

EXHIBITS 29

APPENDIX A/ Increases in Transit Patronage and Car Pools . . . 47

APPENDIX B/ Contra-Flow Lane Projects: Data Sheets 55

APPENDIX C/ Concurrent-Flow Lane Projects: Data Sheets 63

APPENDIX D/ Separate Rights-of-Way Projects: Data Sheets . . . 72

APPENDIX E/ Metered-Ramp Bypass Lanes: Data Sheets 78

LIST OF EXHIBITS

PAGE

Exhibit 1/ FREEWAY MANAGEMENT TECHNIQUES 30
2/ PREFERENTIAL LANE PROJECTS: ASSOCIATED MEASURES . . . 31
3/ CONTRA-FLOW LANE PROJECTS 32
4/ CONTRA-FLOW LANE PROJECTS: CHARACTERISTICS 33
5/ PERSON THROUGHPUT 34
6/ CONCURRENT-FLOW LANE PROJECTS 35
7/ CONCURRENT-FLOW LANE PROJECTS: CHARACTERISTICS . . . 36
8/ SEPARATE RIGHTS-OF-WAY PROJECTS 37
9/ SEPARATE RIGHTS-OF-WAY PROJECTS: FUTURE PLANS 38
10/ SEPARATE RIGHTS-OF-WAY PROJECTS: CHARACTERISTICS . . 39
11/ METERED-RAMP BYPASS LANE PROJECTS 40
12/ METERED-RAMP BYPASS LANE PROJECTS: CHARACTERISTICS . 41
13/ TORONTO FREEWAY CHARACTERISTICS 42
14/ TORONTO AREA 43
15/ HAMILTON & OTTAWA FREEWAY CHARACTERISTICS 44
16/ HAMILTON & OTTAWA 45
17/ COMPARISON OF PREFERENTIAL LANE PROJECTS 46

EXECUTIVE SUMMARY

Numerous projects involving preferential lanes for high occupancy vehicles (HOV) on freeways have been implemented in the USA since the early 1970's. Only one project of this nature has been implemented in Canada -- a Contra-Flow Lane in Montreal, Quebec. This report examines the status of these projects and comments on the possible application of similar treatments in Ontario.

The adoption of a preferential lane for HOV on a freeway is just one method of increasing vehicle occupancy which in turn, is one of three major approaches to alleviating freeway congestion without large capital expenditures. The other major approaches are 'traffic management', i.e., the regulation of traffic flow to minimize the effects of excess demand and freeway incidents, and also 'increasing highway capacity' i.e., the creation of an extra lane by either reducing the width of the existing lanes or utilizing the existing shoulder.

Other methods of increasing vehicle occupancy in the freeway corridor include transit service improvements, provision of special parking lots for HOV, exclusive ramps for HOV, toll plaza preference for HOV, and -- on an area wide basis -- the provision of a ridesharing office offering an area-wide carpool matching service.

• Preferential Lanes for HOV on U.S. Freeways

Preferential lanes for HOV are of four major types: Contra-Flow Lanes, Concurrent-Flow Lanes, Separate Rights-of-Way, and Metered-Ramp Bypass Lanes.

(i) Contra-Flow Lanes

Six projects, ranging in length from 3 to 16 km, are currently in operation. Five of these (including the single Canadian installation on the Champlain Bridge in Montreal) are located on approaches to toll plazas where preference is given to HOV. The remaining project, the Houston North Freeway Contra-Flow Lane, was designed for both buses and vanpools and will be replaced in 1983 by a Separate Right-of-Way facility for buses.

Contra-Flow Lane projects are characterized by low capital costs, minimal required enforcement and high time savings and person throughput. However, accidents and the high operating costs are cause for concern.

(ii) Concurrent-Flow Lanes

Five projects involving the addition of a lane (ranging in length from 3 to 21 km) are currently in operation. (Two other projects involving the reservation of an existing lane for HOV were both cancelled within a year due to public opposition.) Three projects have reduced their hours of operation because of low HOV lane utilization. Two projects have also reduced their carpool qualification for the same reason. The Banfield Expressway project will be replaced by a Separate Right-of-Way facility in 1983.

Concurrent-Flow Lane Projects (Lane Added) have been characterized by high capital costs, minimal time savings, and significant person throughput only where bus volumes have been substantial. Violations are a continuing problem.

(iii) Separate Rights-of-Way

Four projects are currently in operation, three of which allow car-pools. Project lengths vary from 5.5 - 18.0 km. Hours of operation vary from 12 h/d to 24 h/d. The two major projects involve extensive associated measures, e.g., transit service improvements, park-and-ride facilities, exclusive ramps, etc.

Separate Rights-of-Way facilities have been successful in all respects; however, the capital costs have been extremely high.

(iv) Metered-Ramp Bypass Lanes

There are 189 installations of this nature currently in operation, 172 of which are in California. Most projects were implemented as part of a wide-ranging series of measures to increase vehicle occupancy. The remainder were implemented in an attempt to give priority to buses on congested ramps.

Metered-Ramp Bypass Lanes are an inexpensive method of alleviating local congestion; however, violations have been a problem.

• **Implications for Ontario**

Preferential lanes for HOV have all been implemented on heavily travelled freeways in major urban areas. The potential for the use of preferential lanes in Ontario exists only in the three largest municipalities, i.e., Toronto, Hamilton and Ottawa. In Toronto, congestion occurs on most freeways. None of the congested freeways have sufficient space within their medians for the construction of two additional lanes.

A traffic management system (which includes metered ramps) is in effect on the Queen Elizabeth Way approaching Toronto and a system is planned for Highway 401 within the Metropolitan Toronto boundary. Park-and-Ride lots are provided at two subway terminals adjacent to Highway 401 and there are thirteen carpool parking lots adjacent to freeway interchanges at locations ranging from 10 to 97 km from the Metropolitan Toronto boundary.

In Hamilton, the Burlington Skyway is the single congested facility. This structure is scheduled to be widened to ten lanes by 1990. In Ottawa, the Queensway (i.e., Highway 417) suffers congestion. There are approximately 20 express buses in the peak hour and these will transfer to the new transitway once it is opened.

Conclusions reached based on the results obtained are as follows.

i/ Preferential Lanes for HOV have usually been implemented as a means of alleviating congestion and should be examined within the context of an overall Transportation Systems Management Study.

ii/ In a Transportation System Management Study, the relative importance given to maintaining mobility, conserving energy, and improving safety, needs to be decided at the outset.

iii/ Freeway management projects which are perceived to impose net disbenefits on the public are likely to meet strong opposition.

iv/ Preferential Lanes for HOV on freeways need to be accompanied by associated incentives in order to be effective.

v/ Contra-Flow Lane Projects - The minimal bus and vanpool volumes on Ontario freeways, the severe climate, and the lack of suitable directional flows make Contra-Flow Lanes an unlikely prospect on Ontario freeways in the near future.

vi/ Concurrent-Flow Lane Projects: Using Existing Lane - Bearing in mind the anticipated massive congestion, associated public outcry and possible increase in the accident rate on such projects, it is not felt that they are applicable to any Ontario freeways at the present time.

vii/ Concurrent-Flow Lane Projects: Lane Added - There does not appear to be sufficient space within the medians of congested freeways in Ontario to provide for the addition of safe, well enforced Concurrent-Flow Lanes.

viii/ Separate Rights-of-Way -- in Toronto, Ottawa and Hamilton, rapid transit facilities are currently in the planning or design stage in corridors where projected transit volumes warrant construction. The Ottawa transitway is the only system using buses, and the possibility of introducing carpools at a later stage merits consideration.

ix/ Metered-Ramp Bypass Lanes - Such facilities may be considered for implementation on any freeway where metered ramps are proposed. Present opportunities in Ontario are limited to the Queen Elizabeth Way approaching Toronto. A future option for consideration is Highway 401 within Metropolitan Toronto.

1/ INTRODUCTION

High occupancy vehicles (HOV) can be defined as those road vehicles containing more than one person, be they cars, vans or buses. At this time, there are no existing or proposed applications of preferential lanes for high occupancy vehicles on freeways in Ontario. On the other hand, numerous projects of this nature have been implemented in the USA since the early 1970's. It is the intent of this report to examine the various applications in North America and draw conclusions as to the prospects for such treatments in Ontario.

Preferential lanes for HOV on freeways consist of four main categories

i/ Contra-Flow Lane:
a regular lane, having traffic flowing in the opposite direction from the predominant peak flow, which is reserved for HOV in the peak direction.

ii/ Concurrent-Flow Lane:
(also known as 'Normal-Flow' or 'With-Flow' lane)
a lane in the peak direction which is reserved for HOV and is not physically separated from the other general lanes. Such a facility could consist of the reservation of an existing lane or the addition of a new lane.

iii/ Separated Right-of-Way:
lanes for HOV which are physically separated from the regular lanes.

iv/ Metered-Ramp Bypass Lane:
a lane reserved for HOV which bypasses an existing metered on-ramp to a freeway.

The Ontario Ministry of Transportation and Communications has undertaken various preliminary studies related to preferential lanes for HOV on freeways since 1976. These studies indicated that such treatments appeared feasible and recommended further detailed investigation on freeways in the Toronto area.

This report investigates the role of preferential lanes for HOV in the wider context of freeway management. The characteristics of existing projects in the USA and the single project in Canada (the Champlain Bridge Contra-Flow Lane, Montreal) are examined and compared with the situation in regard to Ontario freeways. Finally, conclusions are drawn as to the associated costs and benefits of the various types of preferential lane and comments are made on their applicability in Ontario.

2/ THE ROLE OF PREFERENTIAL LANES FOR HOV IN FREEWAY MANAGEMENT

The adoption of preferential lanes for HOV is just one method of increasing vehicle occupancy which, in turn, is one of two major approaches to alleviating freeway congestion without large capital expenditures (Exhibit 1). These approaches are dealt with below (a third approach, increasing highway capacity for all vehicles by re-striping the existing pavement or using an existing shoulder, is not dealt with in this report).

2.1/ Traffic Management

This technique attempts to cope with both 'non-recurring' problems (incidents such as accidents, disabled vehicles, etc.) and 'recurring problems' (regular congestion caused by excessive demand).

i/ Incident Management

Delays caused by incidents on urban freeways can be as great or greater than those caused by excess demand. Studies of freeway congestion in Detroit, Chicago and Los Angeles in 1979 have indicated that at least one lane in a typical freeway network is likely to be blocked 7.2% of the time due to accidents and 6.2% of the time due to stalled vehicles or breakdowns.

The objectives of incident management are to restore normal service in the shortest practical time and to manage the approaching demand to the particular incident. This is achieved by three distinct actions.

1) Surveillance System - The incident is detected, evaluated and the appropriate action determined. The various methods of surveillance include vehicle detectors, closed circuit TV, aerial surveillance, and telephone boxes.

2) Servicing System - The incident is removed in the shortest practical time. This requires close cooperation between the agencies involved, e.g., police, tow truck operators, etc.

3) Motorist Information System - The approaching motorist is given warning of the incident and directed to an alternative route by means of variable message signs.

ii/ Demand Management

The objective of demand management is to alleviate the regular congestion caused by excessive demand. This is undertaken in three distinct ways

1) Metered Ramps - The flow of traffic entering the freeway is controlled by traffic lights, the entrance rate being determined by the conditions on the adjacent main freeway lanes.

2) Mainline Control - The flow of traffic on the main freeway lanes is controlled by means of traffic lights or variable message signs dictating appropriate speeds.

3) Corridor Control - All routes in the corridor are monitored and traffic diverted from overloaded facilities to those with excess capacity by means of variable message signs.

Freeway traffic management projects covering over 800 km of freeway and employing a total of over 600 ramp meters, are currently in effect in fifteen urban areas in the USA.

2.2/ Increased Vehicle Occupancy

This is achieved by offering ridesharing incentives to the traveller, either specifically for the corridor in question or on an area-wide basis.

i/ Freeway Corridor Incentives

There are numerous measures which can be taken within the freeway corridor. Usually a combination of measures is applied.

1) Preferential Lanes - These are in four main categories as indicated earlier. The choice of category depends on available space within the Right-of-Way, the directional flow, the projected use by HOV, the financial resources available, etc.

2) Transit Service Improvements - These consist of one or more of the following: new express bus routes, shorter headways, and new vehicles.

3) Carpool Parking and/or Park-and-Ride Lots - Although park-and-ride lots have been constructed in conjunction with rapid transit for many years, their establishment in association with express buses is a more recent trend. Special carpool parking lots adjacent to freeway interchanges have grown in popularity since their introduction in the early 1970's.

4) Exclusive Ramps - Usually constructed in association with other measures, they can consist of a completely new facility or merely the re-striping of an existing ramp.

5) Toll Plaza Preference - This is usually given in terms of reduced rates and/or a special toll booth restricted to HOV.

ii/ Area-Wide Incentives

On an area-wide basis, a ridesharing office can contribute to increasing vehicle occupancy on all radial transportation corridors. It is noted that although the basic purpose of such an office is to provide a carpool matching service to the public, the more mature programs offer a whole range of services to employers and the public. Such services include provision of information for the following items: preferential lanes, regional transit schedules, vanpool routes, carpool parking and park-and-ride lots, and toll plaza preference locations. Assistance to employers is often given in terms of parking management, training of transportation coordinators, and the organization of flexible hours. The provision of vans and technical assistance to groups of individuals is another service offered.

In North America, 14 cities have installed preferential lanes for HOV on freeways, comprising 110 km of freeway and approximately 200 metered-ramp bypass lanes (Exhibit 2). Most projects have been undertaken in conjunction with two or more associated measures. It is noted that the majority of Contra-Flow Lane projects have involved transit service improvements, park-and-ride lots, and toll plaza preference. In addition, nearly all the other preferential lane projects involved carpool parking/park-and-ride lot construction and were supported by the services of a ridesharing office.

3/ CONTRA-FLOW LANES

The initial preferential lanes on freeways for HOV were Contra-Flow Lanes and were implemented in the early 1970's (Exhibit 3). The minimum criteria for implemenation were: a sufficient number of buses that would use the lane (generally accepted as being 50/h in order to carry the equivalent of a regular lane with automobiles) and a requirement that the level of service in the non-peak direction be not lower than Level of Service 'C'.

The three New York projects were all characterized by initial bus volumes in excess of 100 vehicles and were all on freeway approaches to toll plazas at entrances to tunnels leading to Manhattan Island. Preference is given to buses at all toll plazas.

The South East Expressway project, Boston, and the Route 101 project, San Francisco, and the Champlain bridge project, Montreal, were attempts to alleviate congestion on overcrowded facilities; bus volumes barely met the minimum criteria. The South East Expressway project only operated during good weather and it was replaced in 1975 by Concurrent-Flow Lanes. The Route 101 project is still in operation, its viability in no small measure being supported by the toll plaza preference at the Oakland Bay Bridge. The Champlain Bridge project surprisingly has managed to continue operations during the winter; the lane has been closed less than 2% of the time.

The Houston North Freeway Contra-Flow Lane is the only project of this nature designed for vehicles other than buses. The huge number of vanpools (over 1500) operating in the area led to their permission to use the facility. In fact, without the vanpools the project would hardly be justified, bearing in mind the relatively low number of buses using the freeway.

The characteristics of the projects (Exhibit 4) are discussed below.

Cost

The capital costs of such projects vary widely depending on the extent of associated measures included and not on the length of the facility. The number of access ramps required, the number of park-and-ride facilities

included, and the complexity of the traffic control system chosen, can increase the capital cost considerably. Similarly, the operating costs do not depend on the length of the facility but on the labour involved in removal and placement of the posts which separate the lane, in breakdown operations, and in enforcement.

Typical costs for installation and operation of a Contra-Flow Lane based on the above is estimated as follows:

Capital Cost: $25 000 - $300 000 (excluding park-and-ride lots)
Operating Costs: $200 000/yr

Time Savings

Time savings are high compared to other types of preferential treatment. Typical savings are in the order of 0.9 to 3.1 min/km. These figures depend on the level of congestion in the general lanes and can increase substantially if there are regular incidents occurring in the general lanes.

Increase in Transit Patronage

The I495 and Long Island Expressway projects in New York had substantial bus volumes at their initiation and, hence, their increases in transit patronage do not appear to be substantial (47% in 11 years and 50% in five years, respectively).

The South East Expressway project, Boston, experienced a 67% increase in transit patronage over the four year life of the installation.

The Route 101 Contra-Flow Lane in San Francisco was combined with a Concurrent-Flow Lane for buses and eventually carpools in 1976 and the emphasis since then has been on carpool formation.

The Champlain Bridge project, Montreal, experienced a 50% rise in transit patronage in three months. This figure dropped somewhat in the winter due to the lack of passenger accommodation at the pick up points.

The most dramatic increase in use has been in Houston where the number of buses and vanpools has risen over 200% in one year.

Peak Period Volumes

In terms of person throughput, such facilities are highly effective (Exhibit 5). The New York projects are carrying from 5300 - 22 000 people in the peak hour. The Houston North Freeway, Route 101, and Champlain Bridge facilities are carrying the equivalent number of persons as a general lane at capacity (2 600 people in the peak hour).

Violations and Accidents

Because of the nature of the operation, the violation rates (i.e., the percentage of vehicles in the HOV lane which are non-eligible) are minimal on such projects.

Accident rates have been low, but fatal accidents attributable to the lane have occurred in most projects. In particular, the Houston project has had three fatal accidents in one year of operation. Vehicles travelling in opposite directions are no longer separated by a physical barrier and the potential for serious accidents is high.

Public Reaction

Public acceptance has been good on all projects. There was some initial adverse reaction to the Boston and Houston projects due to the low usage of the HOV lanes. That pressure subsided as the usage increased.

4/ CONCURRENT-FLOW LANES

After the energy crisis in 1973, the emphasis on carpools and appropriate facilities to promote their use led to numerous Concurrent-Flow Lane projects being implemented in the middle 1970's (Exhibit 6). Several State authorities with freeway widening projects in the design stage decided to restrict the use of the newly constructed lanes to HOV (Moanalua Freeway, Honolulu; Route 101, San Francisco). In other cases, the introduction of up to 100% funding for energy conservation or for demonstration projects was the prime reason for implementation (the Banfield Expressway, Portland; Miami I-95; the Santa Monica Freeway, Los Angeles). The two remaining projects were undertaken as extremely low cost (less than $11 000 capital cost) installations to alleviate congestion (Route 280, San Francisco and the South East Expressway, Boston).

Of seven original installations, two reduced both their hours of operation and their lane qualification; a further installation reduced its hours of operation only. These actions were due to low usage by HOV.

Five of the original seven installations of this kind are currently in operation. The two projects which utilized an existing lane caused substantial increases in travel time to users of the general lanes and the ensuing public opposition resulted in cancellation after a few months. Of the five current projects, only the two installations in San Francisco operate under the same conditions as at their implementation. Low usage led to reductions in lane qualifications and/or operating hours on the Moanalua Freeway, I-95 Miami, and the Banfield Expressway. It is anticipated that the p.m. operation on the Moanalua Freeway will be eliminated in 1981 due to continuing low usage since implemenation.

Future plans in the USA for Concurrent-Flow Lanes include extensions of Route 101 and I-95. In the latter case, it appears that the availability of 90% Federal Funding rather than the achievements of the project is the prime reason for the planned extension. The Banfield Expressway Concurrent-Flow Lanes will be replaced by the Banfield Transitway in 1983 - 1984.

The characteristics of the projects (Exhibit 7) are discussed below.

Cost

The capital costs of the Moanalua Freeway and Route 101 projects cannot be taken as representative since they were part of major reconstruction projects. Similarly, Route 280 did not involve construction costs. The wide variation between the Banfield Expressway and I-95, Miami projects is largely due to the extensive associated measures on the latter project, (a major Park-and-Ride lot, an exclusive ramp, the purchasing of new express buses, etc.). The Santa Monica Freeway and South East Expressway projects utilized existing lanes and are treated separately. The wide variation in operating costs for all projects is due to the items included; the I-95, Miami project operating costs are for bus operations, the Santa Monica Freeway project includes bus operations,and extensive marketing, and a comprehensive evaluation. Operating costs on the South East Expressway were for placing and removing posts (to define the HOV lane) only.

Bearing all the above factors in mind, and considering that the current costs for freeway widening in the Toronto area are estimated at $1 000 000/km, it is felt that typical costs of a project of this nature are as follows:

Capital Cost:	$1 250 000 - $1 850 000/km (lane added)
	$12 500/km (existing lane)
Operating Cost:	$6200/km/year

Time Savings

Typical time savings are from 0.3 to 0.6 min/km -- low compared with Contra-Flow Projects. The exception is the Moanalua Project at 1.25 min/km. Savings in excess of 0.3 min/km often quoted for the Santa Monica Freeway project were due to the associated ramp meters which were installed on that section of freeway before the implementation of the preferential lanes.

Increase in Transit Patronage and Carpooling

The increase in transit patronage has been minimal except where significant transit service improvements were implemented at the same time. In the case of the I-95, Miami project, the transit service improvements had been implemented prior to the opening of the HOV lanes and hence, any increase in transit patronage is not reflected in the figure quoted (8.3% in 4 years). The results for the Santa Monica Freeway project and the South East Expressway project cannot be taken as representative.

A representative increase in the total number of carpools in the peak periods on Concurrent-Flow Lanes appears to be in the order of 150% in three years for three-person carpools and 30% in two years for two-person carpools. These figures reflect the difference in the respective numbers of three-person carpools and two-persons carpools at implementation (On the I-95, Miami project, there were approximately 1050 three-person carpools in the a.m. and p.m. peak periods at implementation. At the time that it was decided to lower the carpool qualification, there were approximately 5500, two-person carpools in the a.m. and p.m. peak periods). It is interesting to note that on the I-95, Miami project, only 33% of the eligible carpools utilized the HOV lane (this was common to the three-person carpool phase and to the two-person carpool phase).

It is not clear how many carpools were newly formed and how many were diverted from other facilities. In the case of the Santa Monica Freeway project, a public survey indicated that only 8% of the new carpools were due to the HOV lane. In most of the other projects where surveys were undertaken of carpoolers, 'cost' was the main reason for carpooling. Only in the Moanalua Freeway project did respondents refer to time savings due to the HOV lane as being an important factor in their decision to carpool.

Peak Hour Volumes

Lane usage, as might be expected, is highest on a facility allowing two-person carpools, i.e., the Banfield Expressway project. The second highest usage is on the Moanalua Freeway project. This is not too surprizing bearing in mind the high travel time savings in this project. Considering the differences in lane qualification, it is more relevant

to examine the person throughput (Exhibit 5). The Route 101 project, because of the high bus volume, carries over 5000 people in the peak hour in 500 vehicles, compared to 2600 people in 1000 vehicles on the Banfield Freeway Project. In fact, after more than five years of operation for all projects, only the Route 101 and the Moanalua Freeway projects are carrying in excess of 2600 people in the peak hour.

Violations

The violation rate depends on the extent of enforcement applied and on lane usage. Initial rates were as high as 80%. The current high violation rates on the I-95, Miami project are due to the difficulty in enforcement caused by the lack of a median shoulder. In the case of the Route 280 project, the high rate is probably due to the extremely low HOV lane use. On the remaining current projects, random saturation enforcement has reduced the violation rate below 10%.

Accidents

On the current projects there has been no increase in the accident rate, apart from on the I-95, Miami installation. This high rate has been attributed to the lack of a median shoulder. There are currently plans to re-stripe the pavement, narrowing the general lanes in order to provide a 2.4 m median shoulder adjacent to the HOV lanes.

Public Reaction

The substantial public opposition to the two projects where existing lanes were reserved for HOV led to cancellation of such projects. Low usage of the Banfield and I-95 HOV lanes created public opposition which diminished when the lane qualification was reduced. The Moanalua Freeway and the Route 101 HOV lanes are well used, well enforced, and generate no opposition. The lack of complaints concerning the Route 280 HOV lane is surprising bearing in mind the low usage.

5/ SEPARATE RIGHTS-OF-WAY

There are four projects of this type in operation at this time (Exhibit 8). The initial two projects, the Shirley Highway and the San Bernadino Freeway, were major ventures involving bus stations, exclusive ramps at interchanges, new bus purchases, etc., and were both funded to a large degree under the federal government's demonstration program. In addition, both projects allowed carpools at a later date. The Route 580 project was initiated as part of the construction of a new highway at which time it was decided to reserve the new lanes for HOV. The South Busway was designed specifically for buses on their own right-of-way, away from any freeways. (The right-of-way, in fact, is shared with a streetcar line and it is, thus, highly improbable that the facility will be opened to car or vanpools.)

Apart from the Route 580 project which has experienced extremely low usage, all installations are considered successful and numerous projects of this type are planned over the next eight years (Exhibit 9).

Characteristics of all current projects are examined as follows (Exhibit 10).

Cost

The South Busway involved expensive structures because of the nature of the topography in Pittsburgh. The capital costs of the Shirley Highway and the San Bernadino Freeway HOV lanes may be regarded as more representative of projects of this nature. These latter projects, as mentioned earlier, involved extensive associated measures. Operating costs are available only for the Shirley Highway: the major portion of these costs (90%) is for the enforcement of the HOV lanes; the remaining costs are for operating the gates to control the reversible lanes.

Assuming a total inflation of 40% over the last five years, typical costs of such a project are estimated to be as follows:

Capital Cost: $4 500 000/km
Operating Cost: $11 000/km/yr

Time Savings

Typical time savings, based again on the Shirley Highway and the San Bernadino HOV lanes, are in the order of 0.9 min/km (resulting in a total time saving of over 16 min on each of these two projects).

Increase in Transit Patronage and Carpools

The increase in transit patronage on both the Shirley Highway and San Bernadino Freeway projects was initially very high (over 300% in four years). In the four years after the time that carpools were introduced in both projects, the increase in transit patronage was only 25% - 40%. It appears, however, that the patronage was stabilized at the time carpools were introduced on both projects, i.e., four years after initial implementation.

The increase in carpools on both projects was from 200% - 400% in four years. (It must be mentioned though that these percentages refer to carpools actually travelling in the HOV lane, whereas the figures given for the Concurrent-Flow Lanes refer to the total number of carpools on the freeway.)

It was found during a survey that while people were forming carpools, a substantial number of carpools switched to driving alone and, also, a substantial number of bus passengers switched to driving alone. Thus, determination of modal shift and, from that, attributable energy savings, is hard to determine.

Peak Hour Volumes in HOV Lanes

The Shirley Highway HOV lanes are carrying over 3000 HOV in the a.m. peak in two lanes, compared with 1200 HOV on the San Bernadino in one lane. The latter facility is estimated to have a capacity of 1400 HOV/h. Above this figure, it is calculated that the lane speed will begin dropping below 90 km/h. The Route 580 lanes, on the other hand, are carrying less than 150 HOV in the peak hour after three years of operation.

In terms of person throughput, the Shirley Highway, because of its two lanes, high bus volumes, and four-person carpool qualification, carries over 21 000 people in the peak hour -- three times the volume on the San Bernadino HOV lane (Exhibit 5).

Violations

Violations on the Shirley Highway and the San Bernadino Freeway projects are minimal due to the continuous concrete barriers separating the HOV lanes from the general freeway lanes. On the Route 580 project, where the separation of the HOV lane is defined by pylons only, the violation rate is in the order of 30%.

Accidents

Accidents are minimal on all installations. The single major accident in the South Busway was due to a conflict between buses and streetcars.

Public Reaction

Even though the Shirley Highway HOV lanes enjoy extremely high usage, 60% of the users travel on the facility between 07:00 a.m. and 08:00 a.m., resulting in periods when the lanes are almost empty. This has led to pressure to lower the carpool qualification.

As may be expected, there has been strong pressure to lower the carpool qualification on Route 580 which has resulted in Caltrans undertaking a study to determine the best use of the HOV lane.

6/ METERED-RAMP BYPASS LANES

Currently, there are 189 such installations in the USA (Exhibit 11). California has the major share with a total of 172 in three metropolitan areas. In that State, they are regarded as just one small part of a larger series of ridesharing incentives. Individual installations, State transportation officials admit, would not be justified. Before implementation the following factors are considered: use of metered ramp by HOV, potential for a park-and-ride lot and, most important, whether the project can be implemented without new construction being required (i.e., merely re-striping). It is worthwhile to point out that in addition to reserved lanes for HOV on freeways, and numerous park-and-ride and carpool parking lots, the three cities mentioned (Los Angeles, San Diego and San Francisco) have established ridesharing offices offering a comprehensive series of services to employers and the public.

The six Metered-Ramp Bypass Lanes in Milwaukee, Dallas, and Houston are for buses only and were implemented on existing metered ramps in response to requests from the local transit agencies. In Minneapolis, the initial eight installations were for buses only and were part of a federal demonstration program for I-35W involving a traffic management system and major transit service improvements. Several installations were implemented for both buses and carpools at a later date.

Future installations are planned in Los Angeles, San Francisco, San Diego, and Minneapolis. In addition, Portland and Sacramento intend implementing their first ramp meters and Metered-Ramp Bypass Lanes (for buses and carpools). Characteristics of the existing projects are examined below (Exhibit 12).

Cost

Costs vary, depending on whether new construction is required. The typical cost of an installation is $5000 - $35 000. Operating costs are minimal.

Time Savings

Typical time savings are from 2-6 min.

Ramp Use

The ramp use in peak hours varies from 10 buses on the ramp in Minneapolis to over 350 buses and carpools on a ramp in Los Angeles. It would appear that typical minimum usage would be in the order of 8-10 buses and/or 100 carpools. Transportation officials have been unable to measure the carpool formation or increased transit use due to the Metered-Ramp Bypass Lane alone.

Violations

Violations are a problem with installations of this nature, reaching levels of up to 50% on bus and carpool bypass lanes. Bus-only bypass ramps do not usually experience violation rates of the same order except in Houston. A study is currently underway in Los Angeles to determine the most appropriate level of enforcement.

Public Reaction

Generally the installations have not caused any significant public reaction.

7.0/ ONTARIO FREEWAY CHARACTERISTICS

All the preferential treatment measures for HOV on North American freeways have been located on radial commuter freeways in and around metropolitan areas with populations in excess of 750 000 people. In Ontario, only Toronto falls into this category; Ottawa and Hamilton have populations in excess of 400 000 people, while London and Mississauga contain over 250 000 people. London has no radial freeways and Mississauga can be viewed as part of the Toronto commutershed. Hence, it would appear that any opportunities for preferential treatment for HOV on freeways would be in the three largest urban areas (Toronto, Ottawa, and Hamilton). The characteristics of the freeways in these areas are examined in detail as follows.

7.1/ Toronto

In this area, the freeways carrying commuters into the city come under both provincial and municipal jurisdiction. The provincial freeways are Highway 400, 401, 404, 409, 427 and the Queen Elizabeth Way. The Metropolitan Toronto freeways are the Don Valley Parkway and the Gardiner Expressway (Exhibit 13 and 14).

Congestion occurs on all freeways in the Toronto area apart from Highways 400, 404 and 409. Only Highways 404 and 409 have sufficient existing space within the median (13 m) for widening by two extra lanes. The congested facilities are examined in detail as follows.

Highway 401

A comprehensive traffic management system on the section between Highway 427 and Port Union Rd. (within Metropolitan Toronto) is currently in the planning stage. Metered ramps and associated bypass lanes for HOV are regarded as options for future consideration. Other types of preferential lanes for HOV were not investigated because of the lack of a continuous lane throughout the section.

The six-eight lane section from Highway 427 west to Mississauga Rd. currently suffers extreme congestion during peak periods. This

congestion will increase in 1982 once Highway 403 is completed to the Queen Elizabeth Way. There are plans to build a core-collector system from Highway 427 (Renforth Drive) to beyond Highway 10. Construction is expected to begin in 1982. The section between Highway 427 and Highway 409 which is now 10 lanes, cannot be widened further without causing extensive property damage. At the Highway 427 interchange, there are only six 'through' lanes.

The six lane section from Highway 48 east to Brock Rd. in Whitby is also congested during peak periods. There are no provisions for widening this section in the five-year construction program although the ultimate plans for the facility envisage a core-collector system.

There are currently three carpool parking lots adjacent to Highway 401 west of Toronto and a further two east of Toronto. Park-and-Ride facilities are provided at two locations adjacent to Highway 401 within Metropolitan Toronto at the Wilson and York Mills Subway Stations. In addition, similar facilities are provided in Ajax, Whitby, and Oshawa for the express GO bus services to Toronto.

Queen Elizabeth Way

Since 1976, the MTC has been increasing (and improving) the area of freeway covered by traffic management techniques in order to alleviate congestion. By 1982, this area will stretch from Cawthra Rd. west to Ford Drive. At this time, Highway 403 will be opened from the Queen Elizabeth Way at Ford Drive to Highway 401. It is hoped that this occurrence will lower the demand on the QEW to acceptable levels.

A single metered-ramp bypass lane was proposed by MTC for Mississauga Rd. North in 1978 but its implementation was not supported by the City of Mississauga.

There are three carpool parking lots adjacent to the Queen Elizabeth Way between Mississauga and Burlington. Park-and-Ride facilities are provided in Bronte (Oakville) and in Burlington.

Metropolitan Toronto Freeways

Freeway traffic management techniques have been proposed for the Gardiner Expressway on several occasions since 1970, as there is some spare capacity on Lakeshore Boulevard, but no action has been taken. Two ramps are presently closed during peak hours. There do not appear to be any plans for future application of freeway traffic management techniques.

No freeway traffic management techniques have been applied on the Don Valley Parkway and there are no plans for any in the immediate future.

Toronto Area Ridesharing Office

A ridesharing office for the Toronto commutershed providing area-wide carpool matching to, initially, employers and, ultimately, the public is currently under study.

7.2/ Hamilton and Ottawa

The freeways in these areas consist of: Highway 403 and the Queen Elizabeth Way in Hamilton and the Queensway (Highway 417) in Ottawa. (Exhibits 15 and 16).

No congestion is experienced on Highway 403 although there is available space within the median for one additional lane should it be required at some future date.

The other two freeways suffer congestion and are examined as follows.

Queen Elizabeth Way, Hamilton

The Burlington Skyway suffers severe congestion in peak periods in both directions. The 3% grade reduces lane capacity and the exposure to high winds causes the facility to be closed on occasion. It is intended that the existing structure be widened (from the current four lanes) to ten lanes by 1990. Construction is anticipated to commence in 1984. Interim measures include a four lane at-grade alternative route (now under construction) and a motorist information system (in the planning stage).

There are no carpool parking or park-and-ride lots currently serving commuters to Hamilton.

The Queensway, Ottawa

Freeway traffic management techniques were recommended as possible solutions to the congestion problems on this facility in 1972. At that time, the City of Ottawa found the recommendations unacceptable.

In addition to the above, the Queensway was investigated as to its suitability for the application of exclusive lanes in 1978 as part of the Ottawa-Carleton Rapid Transit Development Program. The possibility of Contra-Flow Lanes was examined from the Nicholas Street interchange easterly and rejected because of insufficient capacity on the remaining lanes. In addition, the Queensway further west of Nicholas Street was examined as one possible route for the proposed transitway, i.e., a separate right-of-way. This suggestion also was rejected because of the extensive widening of the bridge structures involved. Express buses using the facility will transfer to the transitway once it is opened.

There are no carpool parking lots or park and ride lots in the Ottawa commutershed. However several express bus routes originate in shopping plazas where parking is available.

8/ CONCLUSION

In this investigation, the review of preferential lane projects in the USA and the subsequent examination of urban freeways in Ontario has led to both general conclusions on preferential lanes and specific conclusions on the various individual types.

8.1/ General Conclusions

i/ Preferential Lanes for HOV (and other freeway corridor incentives to increase vehicle occupancy) should be examined within a Transportation Systems Management (i.e., Freeway Management) framework.

Increasing vehicle occupancy by means of providing preferential treatment for HOV and the adoption of traffic management techniques are the two major approaches in the alleviation of freeway congestion. The costs and benefits of each technique need to be investigated to determine its suitability in solving the problems in the specific freeway corridor.

ii/ The overall goals of any freeway management project in terms of mobility, energy conservation and safety should be decided at the outset in order to select the appropriate solutions.

In order to determine the appropriate technique in a freeway corridor, it is important to determine the goals of the project, i.e., the relative importance of maintaining mobility versus conserving energy versus improving safety. If the maintenance of mobility is a major goal, then traffic management techniques may be a more suitable solution than attempting to increase vehicle occupancy. If energy savings are a major goal, the solution may be a combination of traffic management techniques and incentives to increase vehicle occupancy.

iii/ A freeway management project should not impose net perceived disbenefits on the public.

Reservation of existing freeway lanes for HOV which result in massive congestion, reservation of newly constructed freeway lanes

for HOV which result in low usage, metered ramps which cause long queues to entering traffic -- all these techniques have been perceived as disbenefits to the general public and have caused substantial opposition. Unless the benefits of such measures can be made acceptable to the public it may be more appropriate to adopt alternative techniques.

iv/ Preferential Lanes for HOV on freeways should be accompanied by associated incentives.

- Successful Contra-Flow Lane projects have all been accompanied by transit service improvements, park-and-ride facilities, and, in most cases, have terminated at a toll plaza where HOV are given preferential treatment.

- The Concurrent-FLow Lane Projects currently in operation have all involved park-and-ride or carpool parking lot construction and have been supported by a ridesharing office, offering area-wide carpool matching.

- Metered-Ramp Bypass Lanes have been installed as part of a larger series of incentives or in association with a park-and-ride lot to provide direct freeway entry for express buses.

8.2/ Specific Conclusions

Conclusions regarding the preferential lanes are compared by type in Exhibit 17 and outlined in more detail along with comments on their application in Ontario as below.

i/ Contra-Flow Lanes

The accepted criteria for installation of such projects are regarded as (projected) bus volumes in excess of 50 vehicles/h and a minimum level of service 'C' in the off peak direction of flow. Capital costs are lower than other HOV lanes, enforcement is no problem, violations are minimal, and time savings and person throughput are very high. However, each installation has experienced fatal accidents and operating costs are very high.

The number of buses in the peak hour or freeways approaching any one of Ontario's large urban centres is never greater than 20. In addition, vanpooling is a recent mode of commuter transport and there are probably no more than 100 vanpools in the Toronto region. These factors, combined with the severe climate, the accident problem and the absence of suitable directional traffic flows, make Contra-Flow Lanes an unlikely prospect on Ontario freeways in the near future.

ii/ Concurrent-Flow Lanes

Using Existing Lane: Typical costs in such projects are hard to determine as one of the two projects undertaken incurred substantial costs for transit service improvements and marketing. Maximum time savings were only just over 0.6 min per km. The number of carpoolers increased significantly but extensive enforcement was required. The accident rates increased and the massive congestion caused on the general lanes led to cancellation of both projects. No future facilities of this nature are planned in the USA.

In Ontario, there are probably several freeways where the number of two-person carpools in the peak hour is in the order of 1000. However the number of eligible carpoolers choosing to use the reserved lane may be as low as 35% (as was the case in Miami) which would cause massive congestion on the general lanes. In addition, the overall benefits of Concurrent-Flow Lanes are doubtful.

Using Additional Lane: The capital costs have been four to five times those of Contra-Flow Lanes although operating costs have been minimal. The benefits observed have been minimal. Time savings have generally been low. The person throughput has been high only where there have been established bus volumes. Violations have been a continuing problem. It has been accepted that wide median shoulders are necessary to such facilities in order to alleviate accidents and aid enforcement.

The nominal benefits accorded to Concurrent-Flow lanes are reflected in the fact that there appear to be no plans for future facilities of this

nature in US cities other than in Miami, where funding availability is the major reason for implementation.

There does not appear to be sufficient space within the medians of any congested freeways examined in Ontario to provide Concurrent-Flow Lanes with wide shoulders.

iii/ Separate Rights-of-Way

Such facilities have incurred extremely high capital costs because of the extensive associated measures involved. Operating costs have been minimal. Time savings have been good, accidents and violations minimal, and such projects have gained wide public acceptance. Person throughput is high and this type of facility is the only reserved lane type which has been directly responsible for inducing a significant number of people to carpool. There are currently plans for over 145 km of such projects in seven cities in the USA. Most projects (approximately 113 km) will allow carpools. The minimum criterion for implementation of such facilities has usually been a design volume of 40-60 buses in the peak hour. In addition, busway installations are generally contingent on a CBD employment of at least 50 000 and a metropolitan population of at least 750 000.

Rapid transit facilities are currently in the planning or design stage in Toronto, Ottawa and Hamilton on independent rights-of-way in corridors where projected transit volumes warrant construction. The maximum HOV volumes on existing freeways in the above areas do not warrant such high capital costs. However, the Ottawa transitway is the only system using buses and the possibility of introducing carpools at a later stage merits consideration.

iv/ Metered-Ramp Bypass Lanes

Such facilities are an inexpensive method of alleviating local congestion. Generally, they have been well received by the public and have not led to any increase in the accident rate. Violations have been a problem. It has not, however, been proven that they have led to an

increase in transit patronage or carpooling. Installations have been undertaken as an attempt to provide direct freeway entrance for buses or as one of a wider series of measures to encourage ridesharing.

In Ontario, metered ramps are only in operation on the Queen Elizabeth Way. However, metered ramps have been suggested as options for Highway 401, in Metropolitan Toronto. Preliminary studies have indicated the feasibility of Metered-Ramp Bypass Lanes on the Queen Elizabeth Way. It would seem appropriate to utilize one or more ramps as a demonstration project. In order to put this into practice, the operation, design criteria and project benefits need to be investigated in detail and clearly explained to municipal officials and the general public.

9/ ADDITIONAL SOURCES

References applicable to specific projects are given in the individual data sheets; other more general references are given below.

Bus Use of Highways, Planning and Design Guidelines, NCHRP Report 155 - TRB, 1975.

Evaluation of Freeway High Occupancy Vehicle Lanes and Ramp Metering (Report No. DOT-OST-78-050) US Department of Transportation, December, 1979.

Freeway Traffic Control by Television and Other Electronic Devices, Traffic Engineering Office, Ministry of Transportation and Communications, August, 1977.

Freeway Traffic Management, A.M. Voorhees and Associates for Transportation Research Board, National Research Council, September, 1979.

Highway 401 Corridor Traffic Systems Management Study, Ministry of Transporation and Communications, Ontario, March, 1981.

Ministry of Transportation and Communications, Ontario, Directive C-63 19th November and 1979 re Metric Geometric Design Standards from Director, Design and Construction.

Priority Ramp Evaluation Study. Transit Systems, Ministry of Transportation and Communications, Ontario, March, 1978.

Priority Techniques for High Occupancy Vehicles, State of the Art Overview, US DOT November, 1975.

Priority Treatment for High Occupancy Vehicles in USA, A Review of Recent and Forthcoming Projects, US DOT, August, 1978. (Report No. UMTA-MA-06-0049-78-11).

Ridesharing Facilities and Services, Caltrans, March, 1979.

Safety Evaluation of Priority Techniques for High Occupancy Vehicles (Report No. FHWA-RD-79-59 , Federal Highway Administration, February, 1979.

TSM: An Assessment of Impacts (Report No. UMTA-VA-06-0047), A.M. Voorhees for US DOT, November, 1978.

EXHIBITS

Exhibit 1

Freeway Management Techniques

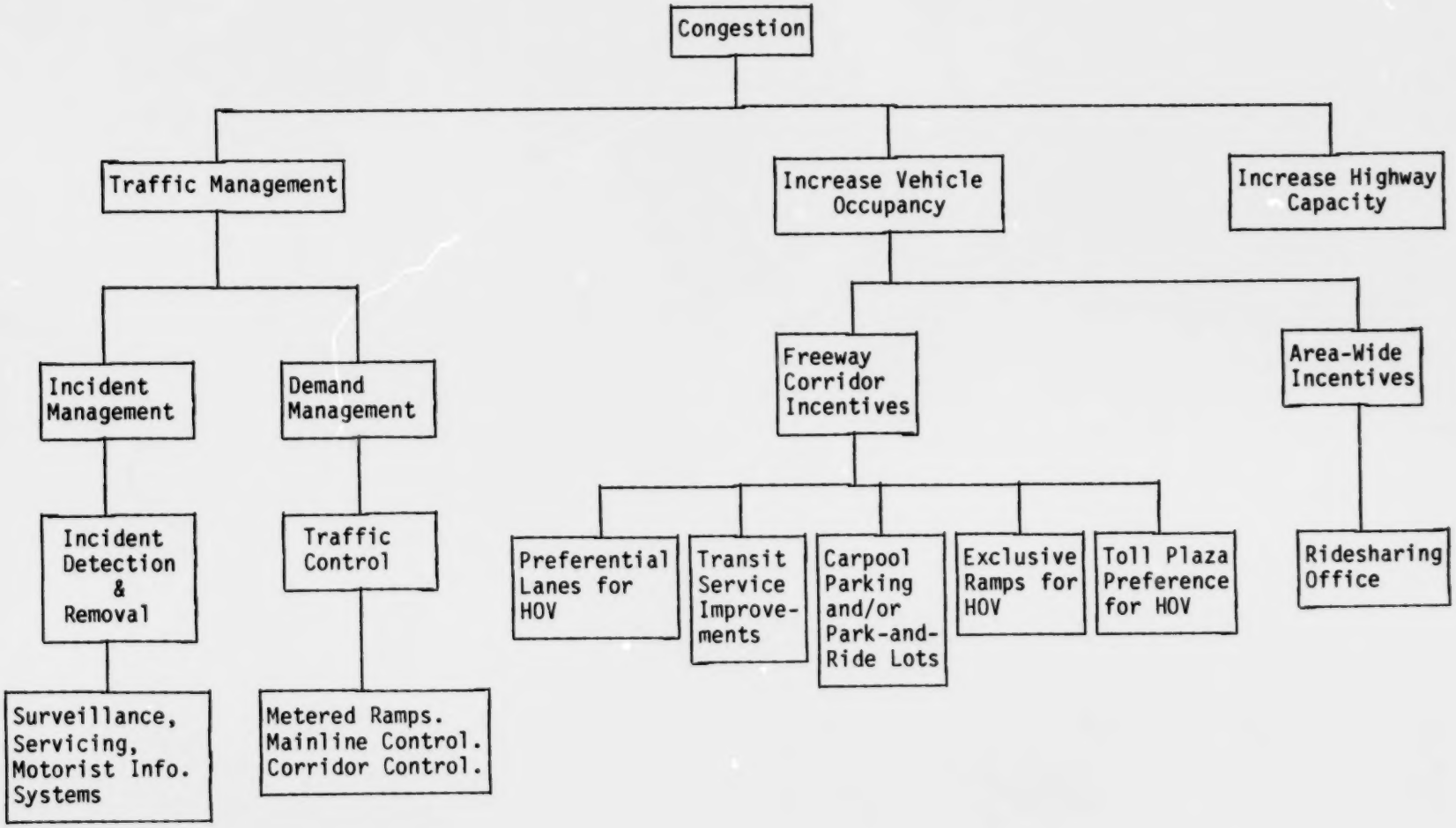


Exhibit 2

Preferential Lane Projects and Associated Measures

Type	Project	FREEWAY CORRIDOR				AREA WIDE
		Transit Improve-ments	Carpool Parking or Park & Ride	Excl. Ramps For HOV	Toll Plaza Pref. for HOV	Ride-Sharing Office
Contra-Flow Lanes	S.E. Expressway, Boston*		o			
	I495, New York	o	o	o	o	
	Route 101, San Francisco	o	o		o	
	Houston North Freeway**	o	o			o
	Gowanus Expressway, NY	o	o		o	
	Long Island Expwy, NY		o		o	
	Champlain Br. Montreal	o	o	o	o	
Con-current Flow Lanes	Moanalua Freeway, Hon.		o			o
	Route 101, San Francisco		o		o	o
	Route 280, San Francisco		o			o
	Banfield Fwy, Portland**	o	o			o
	I95, Miami	o	o	o		o
	Santa Monica Expwy, Los Angeles*	o	o			o
	S. E. Expwy, Boston*		o			o
Separate Rights-of-Way	Shirley Highway, Washington	o	o	o		o
	San Bernadino Fwy, Los Angeles	o	o	o		o
	South Busway, Pittsburgh	o	o	o		NA
	Route 580, San Fransisco					o
Metered-Ramp Bypass Lanes	Various Fwys,Los Angeles	o	o		o	o
	Various Fwys, Milwaukee		o			
	I35W, Minneapolis	o	o			o
	Routes 280, 101, San Francisco		o	NA	o	o
	N. Central Expwy Dallas		o			o
	S. W. Fwy, Houston		o			o
	Various Fwys, San Diego		o			o

NOTE: * cancelled
** to be replaced by rapid transit
NA not applicable

Exhibit 3

Contra-Flow Lane Projects

PROJECT	IMPLEMENTED	LENGTH (km)	VEHICLES PERMITTED	HOURS OF OPERATION
I495, New York	Dec. 1970	4.0	Buses	07:00 to 10:00
South East Expressway, Boston (cancelled 1975)	May 1971	13.5	Buses	06:30 to 09:30
Long Island Expressway New York	Oct. 1971	3.2	Buses, Taxis	07:00 to 09:45
Route 101, Marin County San Francisco	Sept. 1972	6.4	Buses	16:00 to 18:30
Champlain Bridge Montreal	June 1978	7.0	Buses	am and pm peak hours
North Freeway Houston (to be cancelled in 1983)	Aug. 1979	15.4	Buses Vanpools	06:00 to 08:30 and 16:00 to 18:00
Gowanus Expwy New York	Oct. 1980	1.6	Buses Taxis Vanpools	07:00 to 09:30

Exhibit 4

Contra-Flow Lane Projects-Characteristics

Project and Year Implemented	Capital Cost $	Operating Cost per yr $ (1980)	Time Savings min per km	Increase in Transit Patronage		Total a.m. peak period volume	Accidents	Public Reaction
				%	years			
I495 (1970)	654 000	200 000	2.5	47	11	1100B	One fatal accident.	Favourable. Some pressure to open to carpools.
South East Expressway (1971)	39 800	140 000 (1972)	1.2	67	4	95B(1975)	One fatal accident.	Initially adverse.
Long Island Expressway (1971)	44 000	200 000	4.6	50	5	300B 150T	One fatal accident.	Favourable. No pressure to open to carpools.
Route 101 (1972)	180 000	180 000 (1973)	0.3	Unknown		130B	Unknown.	Favourable.
Champlain Bridge (1978)	233 000	120 000	1.3	50	1	145B (1979)	One fatal accident	Favourable
North Freeway (1979)	5 800 000	600 000	0.9	262	1	75B 225VP	Three fatal accidents	Initially adverse due to low use.
Gowanus Expressway (1980)	25 000	200 000	3.1	Unknown		260B 200T 10VP	Unknown.	Favourable.

NOTE: Violations are minimal on all such projects.
KEY: B - Buses VP - Vanpools CP - Taxis T - Carpools

Exhibit 5/ Person Throughput

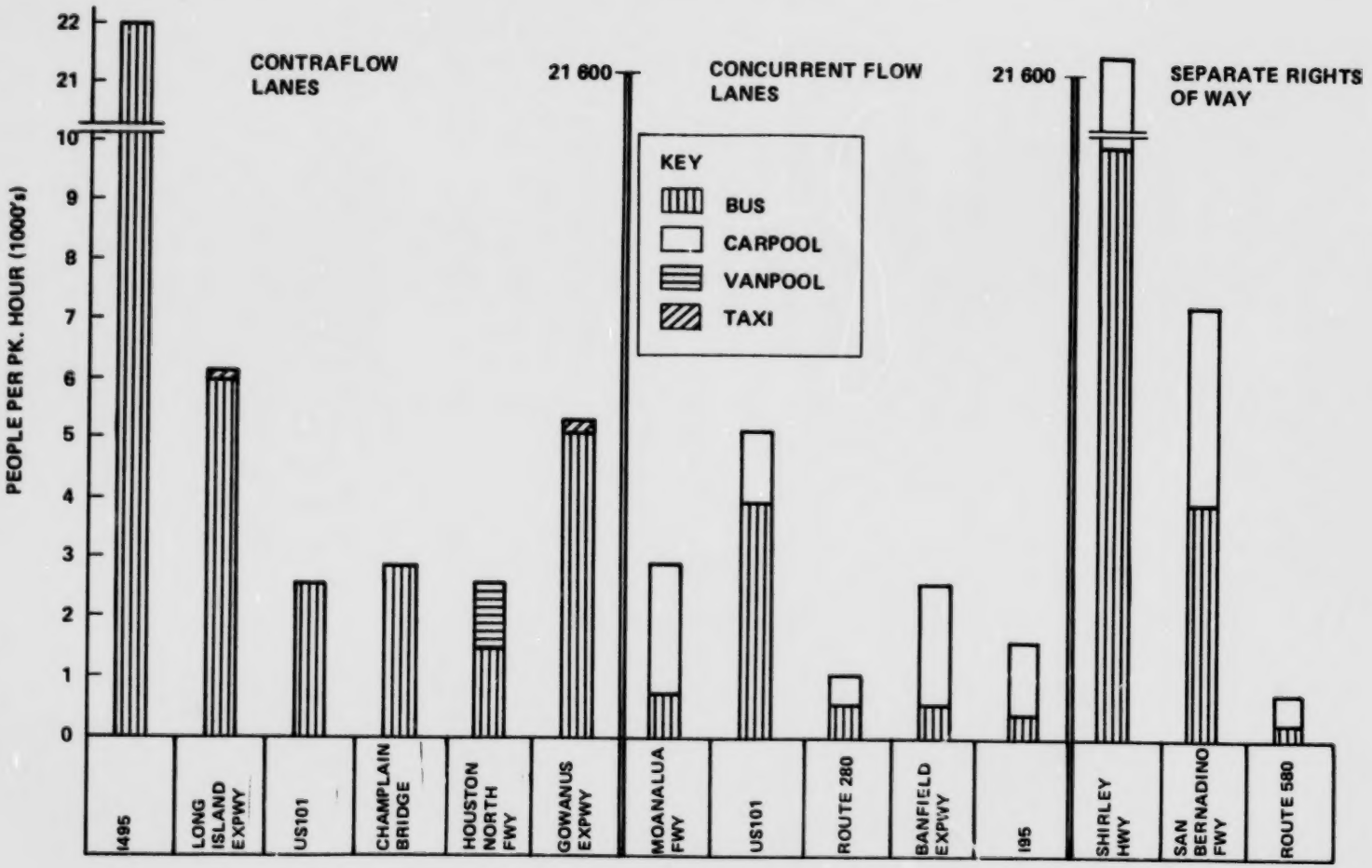


Exhibit 6

Concurrent-Flow Lane Projects

PROJECT	IMPLEMENTED	LENGTH (km)	VEHICLES PERMITTED	HOURS OF OPERATION	COMMENTS
Moanalua Fwy Honolulu	Oct. 1974	4.3 (in) 2.3 (out)	Buses Carpools (3)	06:30 to 08:30 15:30 to 17:30	Built as part of major construction project.
Route 101 Marin Co. San Francisco	Dec. 1974 (Bus) June 1976 (Carpools)	5.9	Buses Carpools (3)	06:00 to 09:00 16:00 to 8:00	As above (no median shoulders).
Route 280, San Francisco	Oct. 1975	3.2 (out)	Buses Carpools (3)	24 h 7 d per week	Minimal capital costs re-striping only.
Banfield Expy Portland (to be cancelled 1983)	Dec. 1975	5.6 (in) 3.2 (out)	Buses Carpools (2)	06:30 to 09:30 15:30 to 18:30	Widening within median-emergency bays at 610 m spacing.
I95, Miami	March 1976	12.1	Buses Carpools (2)	07:00 to 09:00 16:00 to 18:00	Part of Services and Methods Program (no median shoulders).
Santa Monica Fwy Los Angeles (existing lane: cancelled Aug/76)	March 1976	20.3	Buses Carpools (3)	06:30 to 09:30 15:00 to 19:00	Part of Services and Methods Program.
South East Expwy Boston (existing lane; cancelled Nov. 1977)	May 1977	13.5	Buses Carpools (3)	06:30 to 09:30	Previously Contra-Flow lane.

NOTES: 1. Moanalua Freeway Project: Hours of Operation reduced from 24 h. Afternoon operation to be cancelled in 1981.
2. Banfield Expressway Project. Hours of Operation reduced from 8 h per day. Carpool qualification reduced from 3-person carpools.
3. Miami I95 Project. Hours of Operation reduced from 6 h per day. Carpool qualification reduced from 3-person carpools.

Exhibit 7

Concurrent-Flow Lane Projects -- Characteristics

PROJECT AND YEAR	CAPITAL COST/km ($)	OPERATING COST/km/yr ($)	TIME SAVINGS min/km	INCREASE % AND YEARS			PEAK A.M. HOUR VOLUMES IN HOV LANE	VIOLATIONS %		ACCIDENTS	PUBLIC REACTION
				Transit Patronage	Carpools			Initial	Now		
Moanalua Fwy (1974)	8 Million	Minimal	1.2	0.0 (6 yr)	150 (6 yr)		4B 710CP(3)	21	3	Minimal	Pressure to eliminate p.m. operation (low usage).
Route 101 (1974)	502200	Minimal	0.3-0.6	0.0 (6 yr)	Unknown		100B 400CP(3)	15	6-8	No increase due to carpools.	Well accepted since carpools allowed.
Route 280 (1975)	Minimal	Minimal	0.6	0.0 (5 yr)	Unknown		15B 150CP(3)	Unknown	30	No increase.	Complaints about violators.
Banfield Expwy (1976)	88660	Minimal	0.3	50 (4 yr)	(3) 150 (3yr)	(2) 30 (1 1/2yr)	15B 990CP(2)	30	10	Minimal	Low usage by 3-person carpools (<150 veh/h).
I95 (1976)	2 Million	37820	0.2	8 (4 yr)	(3) 31 (9mo)	(2) 18 (6mo)	10B 620CP(2)	75	30	Five fatalities in last few years.	Public pressure forced reduction of qualification to 2-person carpools.
Santa Monica Fwy (1976)	8370	341000	0.06	256 (5 mo)	65.1 (5 mo)		25B 350CP(3)	40	15	Doubled during demonstration.	Extensive adverse reactions led to cancellation.
South East Expwy (1977)	6820	14384	0.7	55 (7 mo)	1000 (7 mo)		45B 580CP(3)	80	35	Slight increase but rate acceptable.	Extensive adverse reaction led to cancellation.

KEY: B - Buses
CP - Carpool

Exhibit 8

Separate Rights-of-Way Projects

PROJECT	IMPLEMENTED	LENGTH (km)	VEHICLES PERMITTED	HOURS OF OPERATION
Shirley Highway (I395) Washington, DC	1969 (Buses) 1973 (Carpools)	17.7	Buses Carpools (4)	23:00 - 11:00 13:00 - 08:00 (weekdays)
San Bernadino Fwy Los Angeles	Jan 1976 (Buses) June 1977 (Carpools)	17.7	Buses Carpools (3)	06:00 - 10:00 and 15:00 - 19:00 (Carpools) 24 h (Buses)
South Busway Pittsburgh	Dec 1977	6.4	Buses	24 h
Route 580 Alameda Co. San Francisco	Dec 1977	5.6	Buses Carpools (3)	06:00 - 18:00

Exhibit 9

Separate Rights-of-Way Projects: Future Plans

PROJECT	CITY	IMPLEMENT-ATION	LENGTH km	VEHICLES PERMITTED	COMMENTS
I66	Washington	1982	16.1	Buses/ Carpools (4)	Under construction.
East Busway	Pittsburgh	1982	11.2	Buses	Under construction.
Banfield Fwy	Portland	1984	4.8	Light Rail Transit	In design stage. It will replace HOV lanes.
North Fwy	Houston	1986	15.4	Buses	In design stage. It will replace HOV lanes.
Route 580	San Francisco	1983	9.6	Buses/ Carpools (3)	West extension under construction. Use by HOV depends on current study.
Route 580		1986	3.2	Buses/ Carpools (3)	Approach to Oakland Bay Bridge, in design stage.
Route 101		1984	6.4	Buses/ Carpools (3)	North extension in design stage.
San Bernadino Fwy	Los Angeles	1984	1.6	Buses/ Carpools (3)	Extension in design stage.
Harbour Fwy		1987	12.8	Unknown	Feasibility study underway
Century Fwy		1988	27.3	Buses Carpools (3)	Construction begins 1981.
Santa Ana Fwy		1988	28.2	Unknown	Feasibility study underway
I15	San Diego	1985	11.2	Unknown	Feasibility study underway
I80	Sacramento	1985	11.2	Light Rail Transit	HOV lanes rejected.

Exhibit 10

Separate Rights-of-Way Projects Characteristics

PROJECT AND YEAR	CAPITAL COST/km ($)	OPERATING COST PER km per yr	TIME SAVINGS min/km	INCREASE %		A.M. PEAK h VOLUMES IN HOV LANE(S)	VIOLATION RATE (%)	ACCIDENTS	PUBLIC REACTION
				Transit Patronage	Carpools				
Shirley Highway (1969)	2.4 Million	12 500	1.0	300 (first four yr) 611 (7 yr)	- 775 (7 yr)	250B 2876CP (4) (2 lanes)	3 Random enforcement	Minimal	Generally well received but some pressure to lower carpool qualification.
San Bernadino Fwy (1973)	3.2 Million	Unknown	0.9	540 (first 4 yr) 25 (4 yr)	- 210 (4 yr)	100B 1100CP (3)	7 Some enforcement	No increase on introduction of carpools.	Well received by public.
Pittsburgh South Busway (1977)	4.1 Million	Unknown	3.7	Unknown	Not applicable	100B	Minimal	One major accident.	Well received by public.
Route 580 San Francisco (1977)	Unknown	Unknown	0.2	Unknown	Unknown	7B 130CP (3)	30	Accident rate decreased.	Strong pressure to lower carpool qualification.

KEY: B - Bus
CP - Carpool

Exhibit 11

Metered-Ramp Bypass Lane Projects

PROJECT	IMPLEMENTED	CITY	EX.NO. BYPASS LANES	VEHICLES PERMITTED	HOURS OF OPERATION	FUTURE PROGRAMS	
						1981	1982-83
Various freeways	From 1973 to present	Los Angeles	8 150	Buses Buses & Carpools (2)	a.m. & p.m. peak hours	50	140
East West Freeway * I43 I94	1975 1978 1978	Milwaukee	1 1 1	Buses Buses Buses	15:30 - 17:30 16:15 - 17:30 07:00 - 09:00	None	None
I35W I35W	1975 1980	Minneapolis	7 4	Buses Buses & Carpools (3)	06:00 - 09:00 06:00 - 09:00 (2) 15:00 - 18:00 (2)	None	4
Route 280 Route 101	1976 1976	San Francisco	1 1	Buses & Carpools (3) Buses & Carpools (3)	a.m. peak hours a.m. peak hours	None	15
N. Central Expwy	1976	Dallas	1	Buses	07:00 - 09:00	None	None
Southwest Fwy	1978	Houston	2	Buses	a.m. & p.m. peak hours	None	None
Route 163 Route 94 Route 8	1978 to 1981	San Diego	1 7 4	Buses & Carpools (2)	a.m. & p.m. peak hours	1	7
I5	-	Portland	-	Buses & Carpools (2)	a.m. & p.m. peak hours	16	8
Route 50	-	Sacramento	-	Buses & Carpools (2)	a.m. & p.m. peak hours	-	4

* Exclusive ramp

Exhibit 12

Metered-Ramp Bypass Lane Projects: Characteristics

CITY	TOTAL NO. OF RAMP METERS	TOTAL NO. OF BYPASS RAMPS	VEHICLES ALLOWED	CAPITAL COST $	TIME SAVINGS MINUTES	RAMP USE IN PEAK HOURS	VIOLATION RATE (%)	PUBLIC REACTION
Los Angeles	520	8	Buses	10 000	1 1/2	50 - 350 B & CP (minimum)	>30	Well received.
		150	Buses & Carpools (2)					
Milwaukee	21	3	Buses	Minimal	2-3	20-35 B	6	None
Minneapolis	54	7	Buses	50 000	2-6	8-10 B	Min	Pressure to open to carpools.
		4	Buses & Carpools (3)			120 B 90 CP (Maximum)	20-50	None
San Francisco	60	2	Buses & Carpools (3)	Up to 15 000	Up to 10	5 B, 100 CP	<10	None
Dallas	39	1	Buses	5000	3	15B	20	None
Houston	56	1	Buses Vanpools	15 000	8-12	12-15 B, VP	70	None
San Diego	39	12	Buses Carpools (2)	35 000	Up to 5	Unknown	<15	Well received.

KEY: B - Buses
CP - Carpools
VP - Vanpools

Exhibit 13

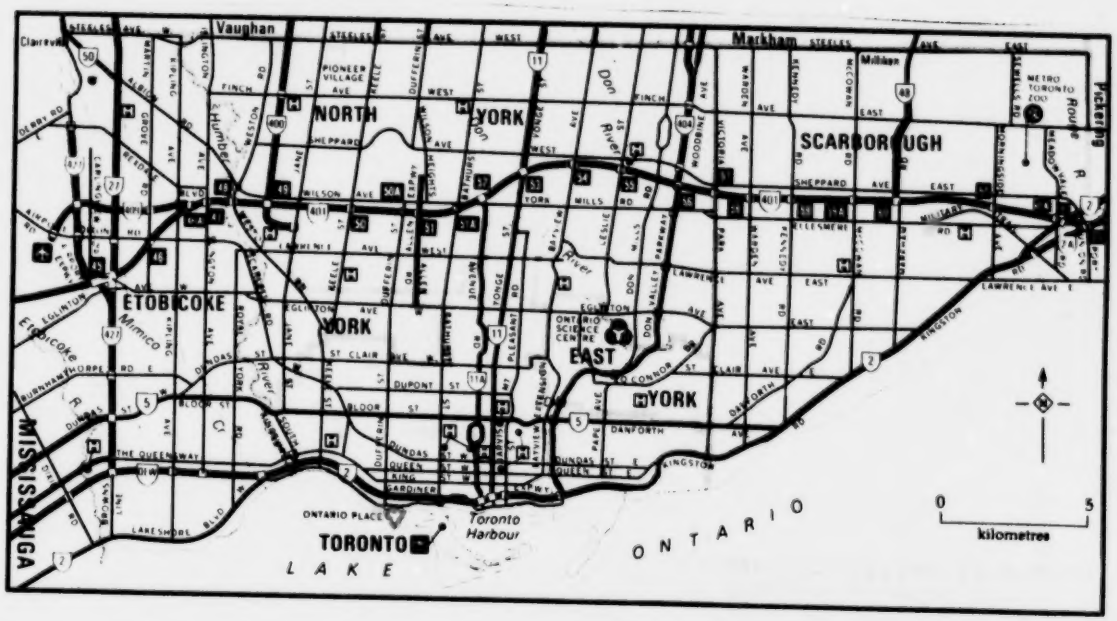
Toronto Freeway Characteristics

FREEWAY	NO. OF LANES	MEDIAN WIDTH (m)	LEVEL OF CONGESTION	FREEWAY TRAFFIC MANAGEMENT	CARPOOL PARKING 1980		PARK-AND-RIDE LOTS (TTC & GO TRANSIT)
					Lots	Spaces	
400	6-8	3.0	Weekends only at ramp to Hwy 401	Possible MTC/ Metro Study in future.	5	304	None. Buses stop at 2 carpool parking lots.
401 West	6-8	3.0 to 8.0	Moderate	None planned (C/D system in design stage).	3	61	None. Buses stop at 1 carpool parking lot.
401 Metro	12	2.7	Moderate	Traffic management system (with optional ramp meters) in planning stage	-	-	Wilson & York Mills subway stations.*
401 East	6	5.5	Moderate	None planned	2	163	Ajax, Whitby and Oshawa
404	6-8	13.0	None	Possible MTC/ Metro Study in future.	-	-	-
409	6	6.7	None	None planned.	-	-	-
427	14	2.7	Some congestion at ramps to QEW & Hwy 401	Eventually when Hwy 401 and QEW Traffic Man. Systems connected.	-	-	-
QEW	6-10	4.3	Severe (Traffic speed 64 km/h for 2h in a.m. peak)	In place for 9.6 km. Ramp meters at 5 interchanges. Hwy 403 will relieve congestion (1982).	3	341	Bronte (Oakville) and Burlington. Buses stop at 2 carpool parking lots.
DON VALLEY PARKWAY AND GARDINER EXPRESSWAY			Severe	Proposed in 1970, 1975. No action.	-	-	-

NOTE: C/D Collector Distributor
* Operated by Toronto Transit Commission (TTC)

Exhibit 14

Toronto Area



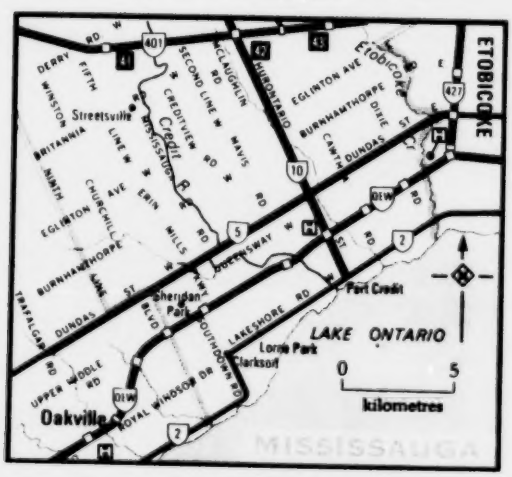


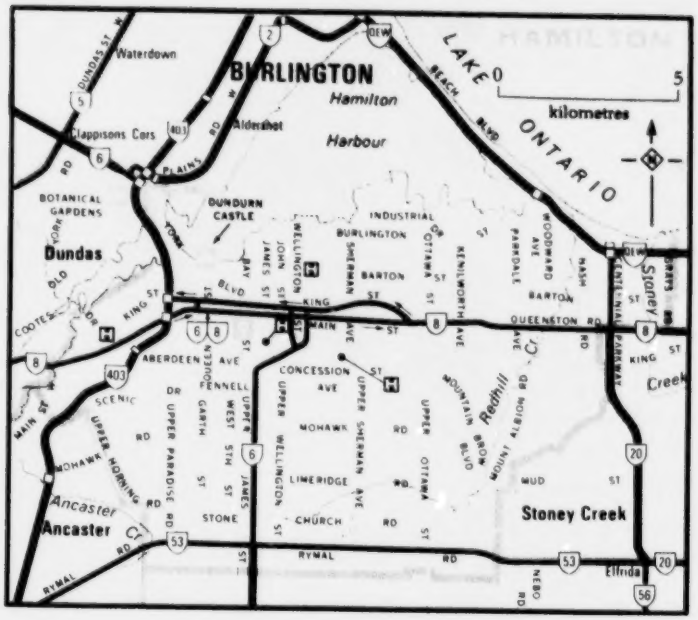
Exhibit 15

Hamilton and Ottawa Freeway Characteristics

FREEWAY	NO. OF LANES	MEDIAN WIDTH (m)	LEVEL OF CONGESTION	FREEWAY TRAFFIC MANAGEMENT	CARPOOL PARKING LOTS 1981	PARK-AND-RIDE LOTS
403 HAMILTON	5-6	7.0	None	None planned.	None	None. Regional Transit Authority only recently formed for Hamilton-Wentworth.
QEW HAMILTON (BURLINGTON) SKYWAY)	4	3.0	Severe	Bridge to be widened to 10 lanes in 1990. Interim measures include motorist information signs.	None	
417 OTTAWA (Queensway)	4-6	2.4 to 9.1	Severe	Proposed by MTC in 1972 and 1978 as being feasible. No action taken.	None	None

Exhibit 16

Hamilton and Ottawa



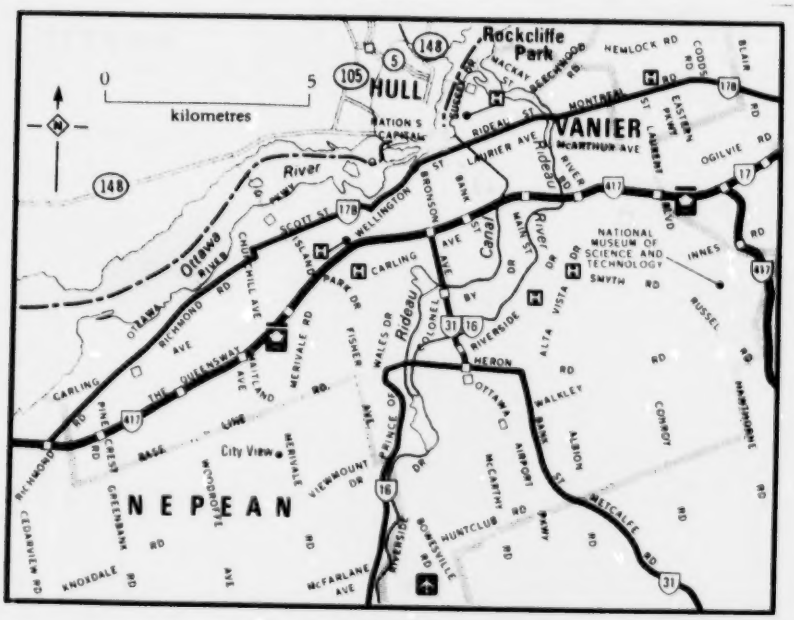


Exhibit 17

Comparison of Preferential Lane Projects

FACTOR		CONTRA-FLOW LANE	CONCURRENT-FLOW LANE	SEPARATE R.O.W.	METERED-RAMP BYPASS LANE
Cost	Capital	$25 000 - $300 000	$1.2 - $1.9 million/km	$4.5 million/km	$5000 - $35 000
	Operating	$200 000/yr	$6200/km/yr	$11 100/km/year	Minimal
Time Savings		0.9 - 3.1 min/km	0.3 - 0.6 min/km	0.9 min/km	2.6 min
Increase in Transit Patronage		Up to 67% after 4 yr	Generally <10% after 4 yr	300% - 540% after 4 yr	Difficult to measure. Most installations are part of a series of measures.
Increase in Number of Carpools		Not applicable.	Up to 150% after 3 yr*** Up to 30% after 2 yr**	200% - 400% after 4 yr	
Person Throughput		2600 - 22000 pph	1200 - 5000 pph	7400 - 22000 pph	300 - 2500 pph
Accidents		All projects have experienced fatal accidents due to HOV lane.	No increase in accident rate if lane added & wide median shoulder provided.	No increase in accident rate.	No increase in accident rate.
Violation Rate*		<5%	Up to 30%. Lack of physical separation encourages violators.	<7%. Physical separation eliminates most violators.	Up to 50%
Public Reaction		Well received. No disbenefits to general lane users.	Acceptable only if lane use is high and no disbenefits to general lane users.	Well received. Benefits to HOV lane users and no disbenefits to general lane users.	Generally acceptable but this may be due to minimal enforcement.

* The proportion of vehicles using the HOV lane that are not eligible.
** 2-person carpools
*** 3-person carpools

Appendix A

Increases in Transit Patronage
and Car Pools

Exhibit A-1

Overall Increase in Transit Patronage

CONTRA-FLOW LANES								
PROJECT	IMPLEMENTATION Date	Peak h Ridership	RECENT MEAS Date	Peak h Ridership	INCREASE	NO. OF YEARS	TOTAL %	AVERAGE % PER YEAR
I495	1969	14000	Dec 1980	22000	8000	11	46.0	4.0
S.E. Expwy	1971	1140	Aug 1975	1900	760	4	67.0	13.1
Long Island Expwy	1975	4000	Dec 1980	6000	2000	5	50.0	8.4
Houston Fwy	Sept 1979	725	Sept 1980	2625	1900	1	262.0	262.0
Champlain Bridge	June 1978	1900	Feb 1979	2700	800	9 mo	42.0	-
CONCURRENT-FLOW LANES								
PROJECT	IMPLEMENTATION Date	Peak h Ridership	RECENT MEAS Date	Peak h Ridership	INCREASE	NO. OF YEARS	TOTAL %	AVERAGE % PER YEAR
Moanalua Fwy	Oct 1974	600	Dec 1980	600	-	6	0.0	0.0
I95	Mar 1976	1570	Mar 1980	1700	1300	4	8.3	2.0
Banfield Expwy	Jan 1976	300	Jan 1980	450	1500	4	50.0	10.7
Santa Monica Fwy	Mar 1976	1068	Aug 1976	3794	2726	5 mo	256.0	-
S.E. Expwy	Mar 1977	3400	Oct 1977	3600	200	7 mo	5.5	-
SEPARATED RIGHTS-OF-WAY								
PROJECT	IMPLEMENTATION Date	Peak h Ridership	RECENT MEAS Date	Peak h Ridership	INCREASE	NO. OF YEARS	TOTAL %	AVERAGE % PER YEAR
Shirley Highway	Sept 1969	1500	Dec 1973	6000	4500	4	300.0	43.9
	Dec 1973	6000	Dec 1980	10 000	4000	7	67.0	7.6
San Bernadino Fwy	Jan 1973	500	Oct 1976	3200	2700	3 3/4	540.0	59.1
	Oct 1976	3200	Dec 1980	4000	800	4	25.0	5.7

Exhibit A-2

Overall Increase in Carpools

CONCURRENT-FLOW LANES								
PROJECT	IMPLEMENTATION Date	No.CPools on Fwy a.m.&p.m.	RECENT MEAS Date	No.CPools on Fwy a.m.&p.m.	INCREASE	NO. OF YEARS	TOTAL %	AVERAGE % BY YEAR
Moanalua Fwy	Oct 1974	615	Dec 1976	1540	925	2	150.0	58.2
Banfield Expwy	Jan 1976 (3 per -son)	440	Mar 1979	1100	660	3	150.0	36
	Mar 1979 (2 per -son)	4500	Oct 1980	5850	1350	18 mo	30.0	16
195	Mar 1976 (3 per -son)	1049	Jan 1977	1371	322	9 mo	30.7	-
	Jan 1977 (2 per -son)	5523	May 1977	6524	1001	6 mo	18.1	-
Santa Monica Fwy	Mar 1976	3479	Aug 1976	5749	2270	5 mo	65.1	-
South East Expwy	Mar 1977	681	Oct 1977	1166	685	7 mo	100.0	-
SEPARATE RIGHTS-OF-WAY								
PROJECT	IMPLEMENTATION Date	No.CPools HOV Lane a.m.Pk h	RECENT MEAS Date	No.CPools HOV Lane a.m.Pk h	INCREASE	NO. OF YEARS	TOTAL %	AVERAGE % PER YEAR
Shirley Highway	Dec 1973	1200	Dec 1980	10 500	9300	7	77.5	36.3
San Bernadino Fwy	Oct 1976	1000	Dec 1980	3100	2100	4	210.0	32.7

Exhibit A-3/ Transit Patronage by Year, Contraflow Lanes

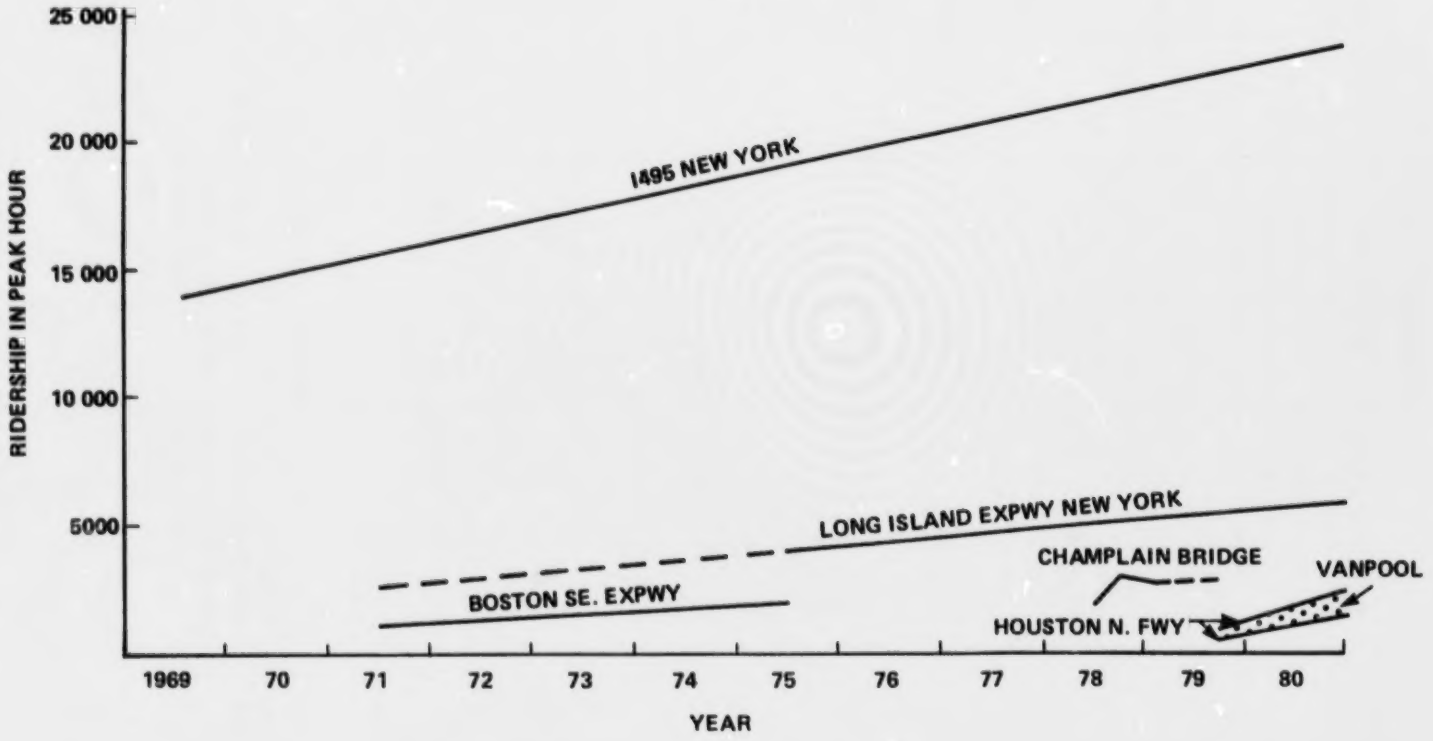


Exhibit A-4/ Transit Patronage by Year, Concurrent Flow Lanes

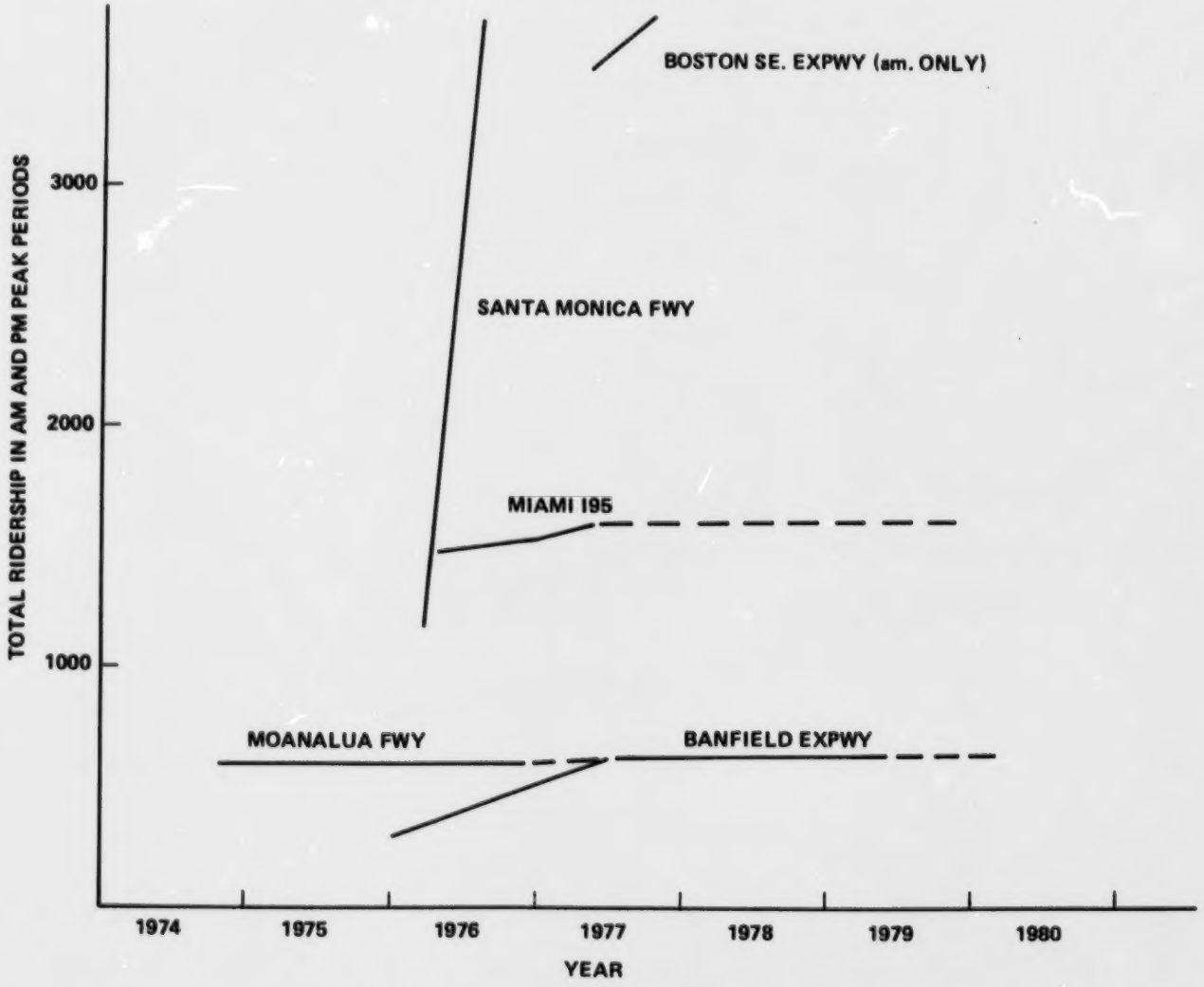


Exhibit A-5/ Carpool Formation, Concurrent Flow Lanes

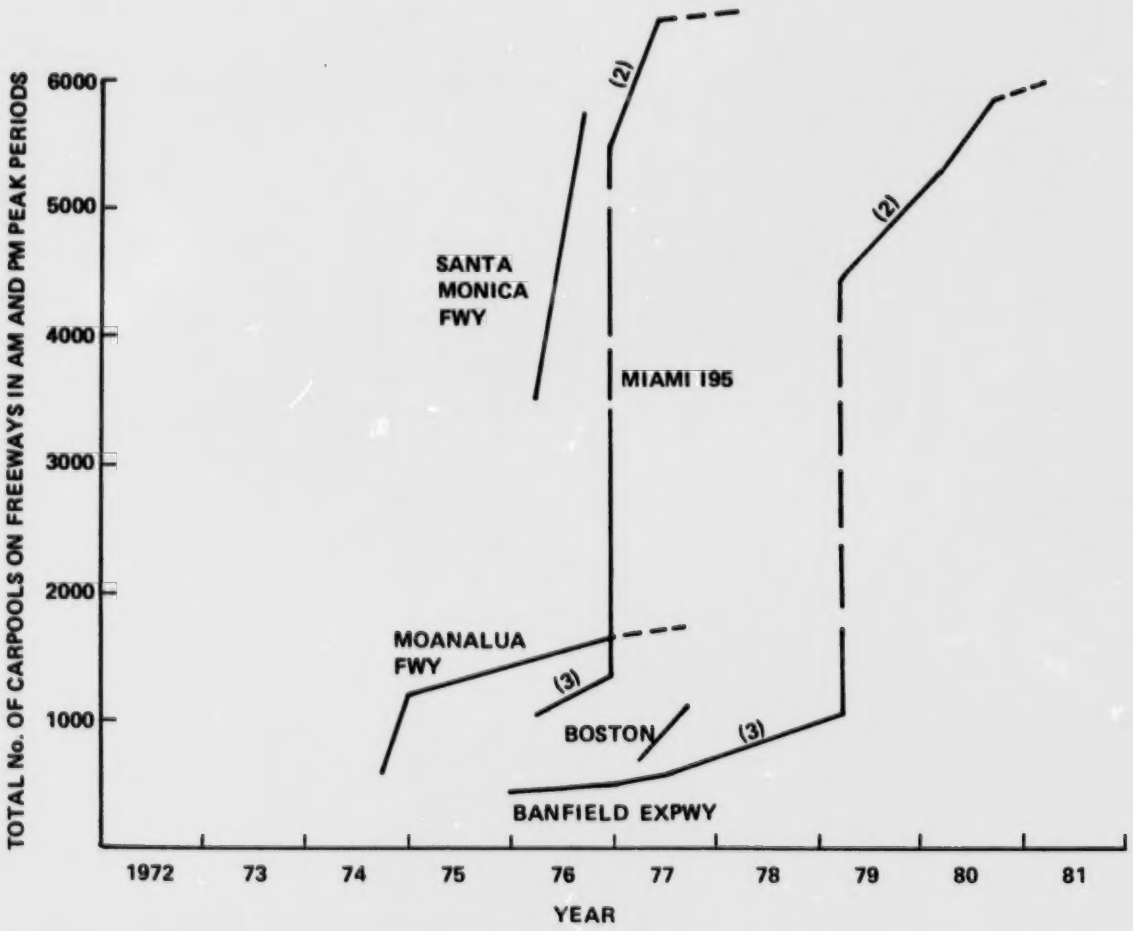


Exhibit A-6/ Carpool Formation and Transit Patronage by Year-Shirley Highway

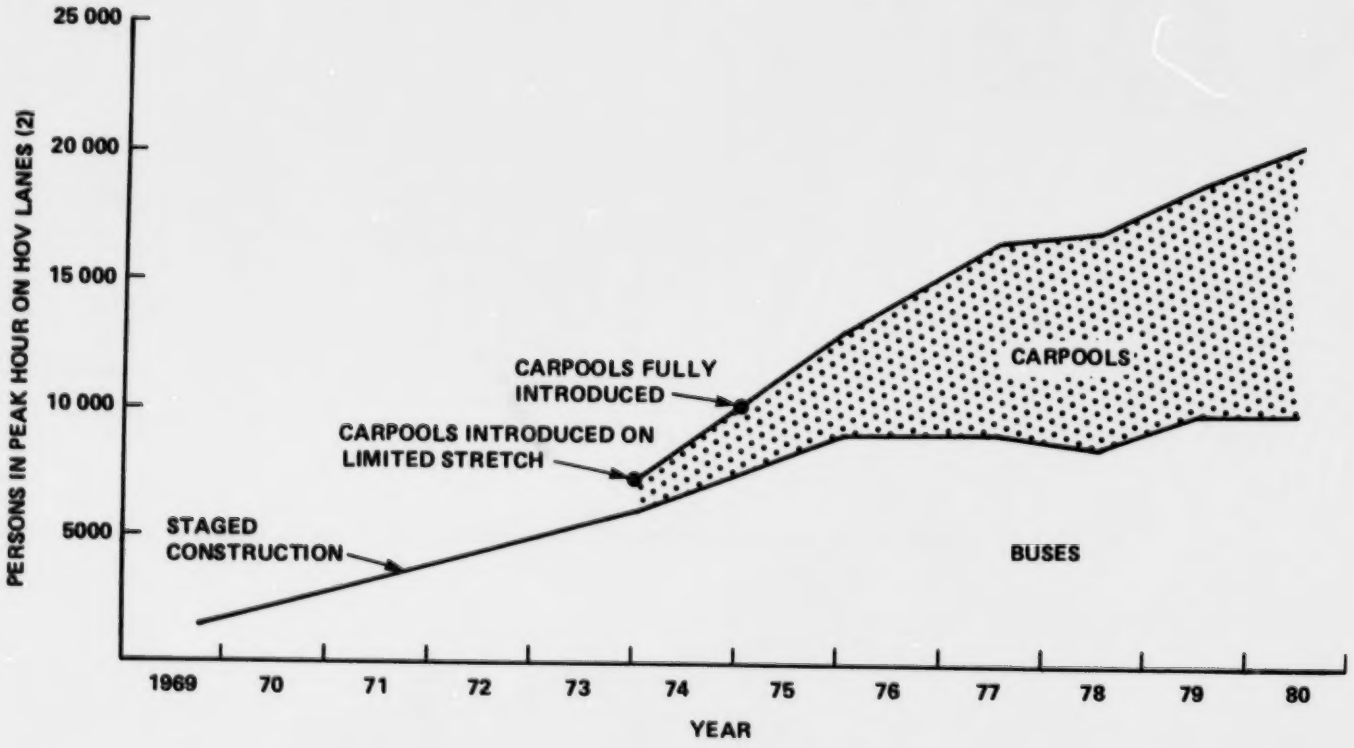
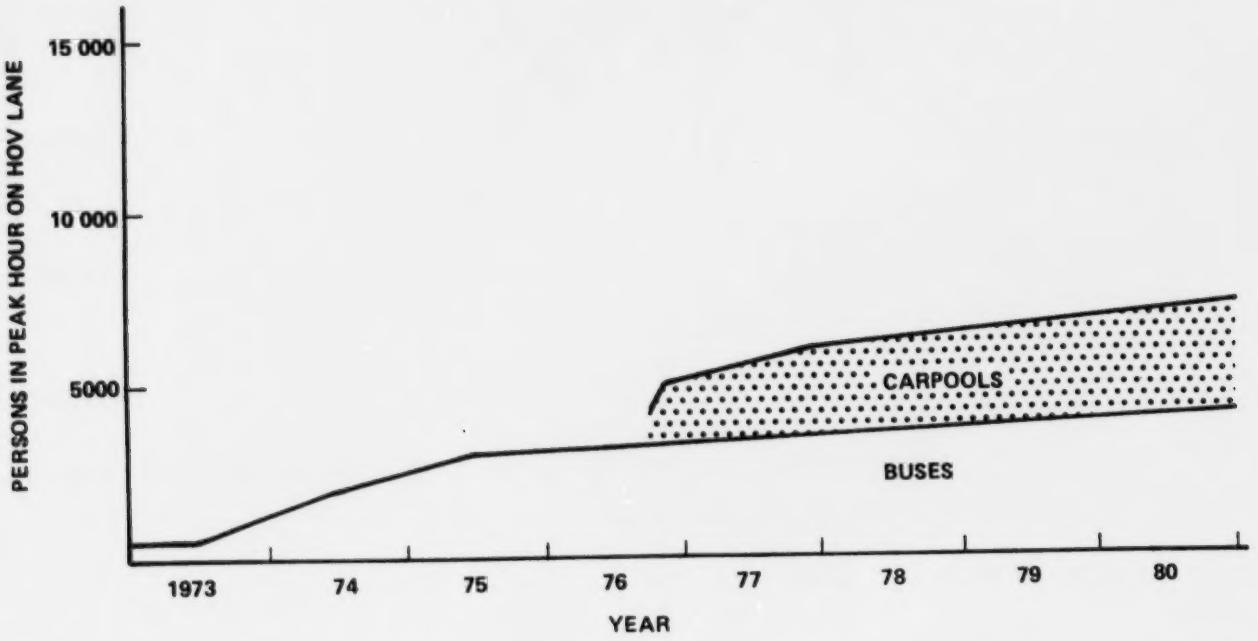


Exhibit A-7/ Carpool Formation and Transit Patronage – San Bernadino Expressway



Appendix B

Contra-Flow Lane Projects

Data Sheets

LOCATION	New York; I495
DESCRIPTION	Contra-flow lane for buses only, leading into toll plaza at entrance to Lincoln Tunnel. Implemented 1970.
REASONS FOR IMPLEMENTATION	Feasibility study in 1967 recommended a bus lane as a means of easing congestion. Project was implemented as part of the 'Urban Corridor Demo Program.'
STATUS	Length: 4 km No. of Lanes: 6 Hours of Operation: 07 00 - 10:00 Construction: separated by removable posts at 12.2 m spacing.
ASSOCIATED MEASURES	Major park-and-ride lot (1600 spaces) adjacent to lane. Exclusive ramp from park-and-ride lot to lane entrance. Exclusive ramp at freeway interchange to lane entrance. Freeway surveillance and control under construction (estimated completion: spring 1981); Toll plaza preference
ORGANIZATIONS INVOLVED	Tri State Regional Planning Commission, New Jersey DOT, Port of New York Authority, New Jersey Turnpike Authority US DOT, Police Depts
COST	Capital: $654 000 Operating: $200 000/yr (1980)
TRAVEL TIME SAVINGS	From 10-25 min (Queues of up to 4 km noticed at entrance to tunnel)
TRAFFIC VOLUMES	1100 buses (3 h peak); 600 buses (07:45 - 08:45) Dec/80
ACCIDENTS	Minimal at this time (one fatal accident since 1970).
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	Favourable. Some pressure to open to carpools and vanpools.
FUTURE PLANS	None.
COMMENTS	Maximum capacity of lane estimated to be 700 buses/h (low figure due to grades and lane width). Hence decision not to open to vanpools and carpools (Current number of vanpools and carpools in 3 h peak = 1500). In 1969 there were 750 buses in the 3 h a m. peak. Estimated energy savings: 1514 L fuel/d due to ease of congestion not counting the persons diverted to transit.
REFERENCE	Telephone Conversation with Mr. Ginseth, Asst. Manager of Transportation Planning Div. Port Authority of New York and New Jersey Dec. 1980 (Tel 212/466-8397) 'I495 Exclusive Bus Lane', Tri State Planning Commission, July 1972

LOCATION	Boston, Massachusetts: South East Expressway
DESCRIPTION	Contra-flow lane for buses only. The South East Expressway runs from the Boston CBD, southerly. Implementation: May 1971
REASONS FOR IMPLEMENTATION	Extreme congestion (Design volumes: 60 000 AADT, Actual volumes 1971: over 105 000 AADT) Investigation in 1970 indicated that level of service on south bound lanes would be Level 'C' if contra-flow lane in place.
STATUS	Length: 13.5 km No. of lanes: 6 Hours of Operation: 06:30 - 09:30 and 16:00 - 18:00 Construction: separated by cones, median openings each end
ASSOCIATED MEASURES	Some Park-and-Ride facilities (details unknown).
ORGANIZATIONS INVOLVED	Massachusetts Dept of Public Works
COST	Construction: $39 800 Operating: $540/d (1972)
TRAVEL TIME SAVINGS	Bus: 14 min (a.m. peak), 4 min (p.m peak) Auto: 4 min (a.m. peak), - - (p.m. peak)
TRAFFIC VOLUMES	Bus: a m peak: 57 (1971); 95 (1975)
ACCIDENTS	No increase in accident rate. One fatal accident.
ENFORCEMENT & VIOLATIONS	Minimal violations: State police stationed at end of lane.
PUBLIC REACTION	Bus passengers favourable (1972).
FUTURE PLANS	None: Project was cancelled in 1975 and converted to 'Concurrent-Flow' Lane in May 1977.
COMMENTS	The lanes only operated from May to September in good weather. Soon after initiation, the p.m. peak operation was cancelled (1972) Travel time savings were estimated $1718/d (1972).
REFERENCE	'Report of the Exclusive Lane Demonstration on the South East Expressway,' Massachusetts Dept of Public Works, 1971 'Priority Techniques for High Occupancy Vehicles' US DOT, Nov 1975

LOCATION	New York: Long Island Expressway
DESCRIPTION	Contra-flow lane for buses and taxis leading into toll plaza at entrance to Queens - Midtown tunnel Implemented: October 1971
REASONS FOR IMPLEMENTATION	Extreme congestion at tunnel entrance
STATUS	Length: 3.2 km No of Lanes: Hours of Operation: 07:00 - 09:45 Construction:
ASSOCIATED MEASURES	No Park-and-Ride lots. Buses operate through residential areas where there is ample space for parking. Toll plaza preference for buses.
ORGANIZATIONS INVOLVED	New York City Dept. of Transportation
COST	Construction $44 000: Operating $200 000/yr (1980)
TRAVEL TIME SAVINGS	Typical 15 min up to 30 min
TRAFFIC VOLUMES	Peak 2.75 h: 300 buses and 250 taxis (1980)
ACCIDENTS	One fatal accident (a taxi in regular lanes skidded into a bus).
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	No pressure to open up to vanpools as numbers mininal.
FUTURE PLANS	None, informal operation.
COMMENTS	Originally for buses only; minimal implementation time. Bus volumes increased from 200 in peak hours (1975). As indicated, this is an informal operation with no expenditures incurred on associated measures.
REFERENCE	Telephone conversation with Joe Richter, New York Dept. of Traffic, Jan. 1981 (Tel. 212-971-0780)

LOCATION	San Francisco, Cal. Route 101 (Marin County)
DESCRIPTION	Contra-flow lane for buses from the Golden Gate Bridge northerly to Richardson Bay Bridge Implemented: Sept. 1972
REASONS FOR IMPLEMENTATION	To bypass congestion caused by incidents on northbound lanes.
STATUS	Length 6.4 km No. of Lanes: 8 Hours of Operation: 16:00 - 18:30 Construction
ASSOCIATED MEASURES	Concurrent-flow lanes from Richardson Bay Bridge 5.9 km northerly New buses purchased at initiation of project and re-routing undertaken. Park-and-Ride facility (75 spaces).
ORGANIZATIONS INVOLVED	Caltrans, Golden Gate Bridge and Transportation District Marin County.
COST	Capital: $180 000 Operating: $5000/mo (1973)
TRAVEL TIME SAVINGS	If a major incident occurs time savings can be up to 10 min Typical 2 min.
TRAFFIC VOLUMES	Pk a.m. period (2.75 h): 130 buses Pk h: 100 buses (1980)
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	None.
FUTURE PLANS	None. The lane continues north as a concurrent-flow facility.
COMMENTS	Surveys indicated that less than 40 people switched to transit because of the lane; of these, half were formerly in carpools. Increase in patronage was due to the transit service improvements. There has been no increase in the number of buses using the lane in the last few years.
REFERENCE	'Freeway Lanes for High Occupancy Vehicles' Dec 1973 Caltrans 'Ridesharing Facilities and Services' March 1979, Caltrans. Telephone conversation with L. Newman, Traffic Operations Caltrans, San Francisco, Jan 1981 (Tel. 415-557-2342)

LOCATION	Montreal: Champlain Bridge
DESCRIPTION	Contra-flow lane for buses from South Shore to Island of Montreal Implemented: June 1978
REASONS FOR IMPLEMENTATION	Extreme congestion on the five St. Lawrence bridges. The Champlain bridge was the only one meeting the criteria for a Contra-Flow Lane.
STATUS	Length: 7 km No of Lanes: 6 Hours of Operation: am & pm peak h Construction: Separated by cones @ 25 m spacing
ASSOCIATED MEASURES	Exclusive ramps (3): Toll plaza preference Park-and-Ride Lot: 500 spaces Transit Improvements: rescheduling and re-routing
ORGANIZATIONS INVOLVED	Montreal South Shore Transit Commission; The National Harbours Board; The St. Lawrence Seaway Authority; The Ministere des Transports du Quebec; the Conseil des Transports de la Region de Montreal, The office des autoroutes du Quebec.
COST	Construction $233 000 Operating $120 000/yr (1979)
TRAVEL TIME SAVINGS	5 min: am peak; 13 min: pm peak
TRAFFIC VOLUMES	May 1978 3800 passengers in am & in pm peak Sept 1978 5800 passengers in am & in pm peak Feb 1979 5250 passengers in am & in pm peak
ACCIDENTS	In first year, only four accidents on reserved lane including one fatality.
ENFORCEMENT & VIOLATIONS	Barriers at median openings. Minimal violations.
PUBLIC REACTION	Public survey April 1979. 17% Riders use. Speed most important factor in choice of mode (82%).
FUTURE PLANS	Extension of lane in Bonaventure Expressway to downtown. Further park-and-ride lots. Automatic lane control (to replace cones)
COMMENTS	Lane closed 12 times in 488 periods of operation (1 yr) due to weather (7) etc. Low winter ridership probably due to poor passenger accommodation. Three-person carpools may be allowed eventually.
REFERENCE	'Reserved Control flow bus Lanes on Champlain Bridge in Montreal' Parenteau, Quy, & Menard Roads & Transportation Assoc. of Canada Convention, Regina Sept. 1979.

LOCATION	Houston, Texas: Houston North Freeway
DESCRIPTION	Contra-flow lane for buses and vanpools: August 1979 from Houston CBD to city limits.
REASONS FOR IMPLEMENTATION	A study of major transportation corridors in Houston in 1975 indicated project was feasible if combined with major Park-and-Ride lots. Project is funded by the UMTA Services and Methods Demo. Program.
STATUS	Length: 15.4 km No. of Lanes: 6 Hours of Operation: 06:00 - 08:30, 16:00 - 18:00 Construction: Separated by pylons @ 12.2 m spacing
ASSOCIATED MEASURES	Park-and-Ride Lots: 3 No. total 2500 spaces (One leased from a church (350 spaces) the other two are newly constructed and contain bus bays, shelters, etc. Transit Improvements Vanpool program (95% vans sponsored by private corporations).
ORGANIZATIONS INVOLVED	Metropolitan Transit Authority of Harris County Texas Highway Dept.
COST	Contra-flow lane $1.8 million. Park-and-Ride lots (2) $4.0 million. Operating cost $50 000/mo.
TRAVEL TIME SAVINGS	15 min (HOV lane speed 90 km/h Reg. lane speed 35.4 km/h)
TRAFFIC VOLUMES	75 buses and 225 vanpools in a.m. peak (Dec. 1980) 20 buses and 65 vanpools in a.m. peak (Aug. 1979)
ACCIDENTS	Three major accidents (fatalities) in first year.
ENFORCEMENT & VIOLATIONS	Police are stationed at the two entry points. Violations minimal, i.e., one per day.
PUBLIC REACTION	Initially adverse due to low use. Minimal complaints at this time.
FUTURE PLANS	Reverse commuting increasing. Hence, the contra-flow lane will be eliminated in 3-5 years and a permanent busway built in the median.
COMMENTS	Initial estimates of HOV use were 25 buses in peak a.m. hours with a growth rate of (2.5 - 3.0 x initial use) in 1 year. No method available to estimate vanpool use. Extra capacity provided has accommodated the increase in person movement in the corridor rather than persuading people to switch modes of travel. Evaluation report due March 1981.
REFERENCE	Telephone conversation with Chuck Fuhs, Coordinator, Contra-flow lane, Metropolitan Transit Authority of Harris County Dec. 1980 (Tel. 713-225-1151)

LOCATION	New York: Gowanus (Brooklyn Queens) Expressway
DESCRIPTION	Contra-flow lane for buses, vanpools and taxis leading into toll plaza at entrance to Brooklyn Battery Tunnel. Implemented: October 1980.
REASONS FOR IMPLEMENTATION	Extreme congestion at tunnel entrance.
STATUS	Length 1 6 km No of Lanes: 8 Hours of operation: 07:00 to 09:30 Construction: separated by posts, entrance through median
ASSOCIATED MEASURES	One Park-and-Ride lot 13 km out (400 spaces) on Staten Island Expwy. Some buses re-routed through this lot - disappointing results. Currently negotiating to use 200 spaces in shopping plaza adjacent to Staten Island Expwy, 21 km out. Toll preference for buses.
ORGANIZATIONS INVOLVED	New York City Dept. of Transportation
COST	Construction: $25 000 (Median crossover) Operating $200 000/yr (1980)
TRAVEL TIME SAVINGS	Typical 5 min (occasionally up to 15 min)
TRAFFIC VOLUMES	In peak 2 5 h: 260 buses, 200 taxis, 10 vanpools (1980)
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	None.
FUTURE PLANS	Intend to reconstruct median crossover and install changeable message signs (cost $300 000). A major promotional campaign is planned at the toll plaza.
COMMENTS	The Park-and-Ride lots mentioned are all existing lots with no capital expenditure involved.
REFERENCE	Telephone conversation with Sam Schwartz, Commissioner and Peter Pennica, Project Engineer, New York City Dept of Transportation (Tel. 212-566-3960)

Appendix C

Concurrent-Flow Lane Projects

Data Sheets

LOCATION	Honolulu, Hawaii Moanalua Freeway
DESCRIPTION	Concurrent-flow reserved lane for buses and carpools (3 or more persons). This freeway is a major commuter route to Honolulu Implemented: October 1974.
REASONS FOR IMPLEMENTATION	There were plans for widening of the facility which were made HOV lanes after the energy crisis in 1973 and the success of other HOV projects.
STATUS	Length 4.3 km (in); 2.2 km (out) No of lanes; 4 & 5 Hours of operation: 06 30 - 08:30 and 15:30 - 17:30 Construction: 2.4 m median shoulder, no separation
ASSOCIATED MEASURES	Carpool matching program discontinued.
ORGANIZATIONS INVOLVED	US DOT Hawaii DOT
COST	Total capital cost incl. grade separations $40 million Operating costs: unknown
TRAVEL TIME SAVINGS	Typical 5 min up to 10 min maximum
TRAFFIC VOLUMES	a.m. peak 2 h: Oct. 1974: 615 veh./Dec 1974: 1220 veh. HOV lane Feb. 1977: 1500 veh.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Initially violation rate 21%, reduced to 3%. Periodic intensive enforcement.
PUBLIC REACTION	Public pressure led to reduction in hours of operation from 24 h. Current pressure to eliminate outbound lanes (low utilization).
FUTURE PLANS	Current study on 1.6 km extension to city limits.
COMMENTS	Only 3% vehicles are buses. Over 73% carpoolers have one child in car and feel time savings very important. The facility is well designed with 3.6 m lanes and 2.4 m shoulders.
REFERENCE	Telephone conversation with A Chow, Highways Branch, Hawaii DOT, Dec 1980 (Tel. 808-548-7530) 'Evaluation of the Moanalua Freeway Bus/Carpool Bypass Lane' Aug. 1977 US DOT.

LOCATION	San Francisco, Cal. Route 101 (Marin County)
DESCRIPTION	Concurrent-flow lanes for buses and carpools (3 or more persons) from Richardson Bay Bridge (end of contra-flow lane) north Implemented: Dec. 1974 (bus) June 1976 (carpools)
REASONS FOR IMPLEMENTATION	After 1973 energy crisis, Golden Gate Bridge Transportation District recommended continuing existing contra-flow lane as concurrent-flow. In Jan. 1976, a State Bill allowed 3-person carpools on bus lanes where feasible.
STATUS	Length: 5.9 km (in and out) No of lanes: 8 Hours of Operation: 06:00 - 09:00 and 16:00 - 19:00 Construction: Median shoulder removed, no separation
ASSOCIATED MEASURES	Contra-flow lane from Richardson Bay Bridge to Golden Gate Bridge. Preferential parking in downtown. Carpool matching, vanpool program. Flexible hours demonstration project. Training program for transportation coordinators for employers.
ORGANIZATIONS INVOLVED	Caltrans, Golden Gate Bridge and Transportation District, Marin County.
COST	Capital Cost: $3 million (total widening cost) Operating Cost: Minimal
TRAVEL TIME SAVINGS	a.m. peak: up to 1.5 min, p.m. peak: up to 4 min
TRAFFIC VOLUMES	a.m. peak: 3 h Buses 220, Carpools, 1420 (total vehicles on freeway) Sept. 1978
ACCIDENTS	Evening peak: accidents doubled since 1974 Morning peak: no change
ENFORCEMENT & VIOLATIONS	Violations: a.m. peak: less than 6% (Special highway patrols) p.m. peak: less than 8%
PUBLIC REACTION	Well accepted since carpools allowed to use lanes.
FUTURE PLANS	A 6.4 km north extension is now in the design stage. The project is anticipated to be completed in 1984.
COMMENTS	On opening to carpools, 1140 carpools and 220 buses were on the freeway in the a.m. peak. The number of carpools has stabilized in the last two years. The accident rate in the a.m. peak has not changed since carpools were allowed. Lack of a median has not contributed to accidents as significantly as in the Miami I95.
REFERENCE	'Ridesharing Facilities and Services March 1979, Caltrans. Telephone conversation with L. Newman, Traffic Operations Caltrans, San Francisco, Jan. 1981 (Tel. 415-557-2342)

LOCATION	San Francisco, Cal. Route 280
DESCRIPTION	Concurrent-flow lane for buses and carpools (3 or more persons) from Sixth St. on ramp, south. Implemented: Oct. 1975
REASONS FOR IMPLEMENTATION	To bypass congestion in p.m. peak period on Route 280 leading out of downtown.
STATUS	Length: 3.2 km (out) No. of lanes: Hr of Operation: 24 h; 7 d per week Construction: restriping; no separation
ASSOCIATED MEASURES	Metered-ramp bypass lane (1 on Route 280, 1 other on Route 101) Park-and-Ride and fringe parking lots (total 22 in area). Carpool matching and Vanpool program. Downtown preferential parking. Flexible hours demonstration project.
ORGANIZATIONS INVOLVED	Caltrans
COST	Capital: Minimal (re-striping only)
TRAVEL TIME SAVINGS	p.m. peak: 2 min
TRAFFIC VOLUMES	p.m. peak hour: Buses, 15; Carpools 150; Violators, 80
ACCIDENTS	No change since implementation.
ENFORCEMENT & VIOLATIONS	Violations in peak: 30%
PUBLIC REACTION	Mininal, other than complaints about violators.
FUTURE PLANS	None for Route 280. Five year program to install ramp meters and bypass lanes in area.
COMMENTS	Daily traffic only 600 vehicles. The peak period (1.5 h) buses and carpools has remained constant over the last five years. This project is basically an efficient way to utilize existing abundant pavement to ease congestion.
REFERENCE	'Ridesharing Facilities and Services' March 1979, Caltrans Telephone conversation with L. Newman, Traffic Operations Caltrans, San Francisco, Jan 1981, (Tel. 415-557-2342)

LOCATION	Portland, Oregon Banfield Freeway
DESCRIPTION	Concurrent-flow reserved lane for buses and carpools (2 or more persons). This freeway is a major commuter facility from the east to downtown Portland and also an interstate route. Implemented: Dec. 1975
REASONS FOR IMPLEMENTATION	Anticipated breakdown on freeway and adjacent arterials. 1974 Fed. Hwy. Energy Act provided funds for urban carpool demo projects.
STATUS	Length: 5.6 km (in) 19.3 km (out) No of lanes: 4 & 6 Hours of Operation: (Reduced from 24 h) 06:30 - 09:30 15:30 - 18:30 Construction: Median shoulder removed, emergency bays at 609.6 m spacing; no physical separation
ASSOCIATED MEASURES	From 20-30 Park-and-Ride lots at east end of project - all leased facilities. Express bus services (Banfield Flyers). Carpool Matching program.
ORGANIZATIONS INVOLVED	Oregon DOT, Dept. of Environmental Quality, Police Tri County Metro Transit District, City of Portland Multnomah Planning Dept., Citizen groups
COST	Capital: $500 000 Operating: Minimal (Extensive media campaign)
TRAVEL TIME SAVINGS	Approx. 1.5 min
TRAFFIC VOLUMES	Oct. 1980 a.m. peak h: 1104 veh. (HOV lane use) p.m. peak h: 871 veh.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Initially for 3-person carpools, violation rate up to 30%. Now for 2-person carpools, violation rate less than 10%.
PUBLIC REACTION	Minimal since qualification changed to 2-person carpools in Feb. 1979.
FUTURE PLANS	The Banfield Transit way will be constructed parallel to the freeway in the North side. The HOV lanes will revert to normal freeway lanes in 1982-1983.
COMMENTS	March 1975: a.m. peak hour: total 105 carpools (3-person), no express buses. March 1977: a.m. peak hour: total 500 carpools (3-person) and 633 bus passengers/day. Public pressure forced reduction in lane qualification. There are no plans for reserved lanes for HOV elsewhere in Oregon.
REFERENCE	Telephone conversation with Earl Mershon, Coordinator, HOV Project, Oregon DOT, Portland, Dec. 1980 (Tel. 503-238-8226) 'Banfield High Occupancy Vehicle Lanes' Oregon DOT for FHWA March 1978.

LOCATION	Miami, Florida I95
DESCRIPTION	Concurrent-flow reserved lane for buses and carpools (2 or more persons) on I95. This freeway is a major commuter facility from residential areas in the north to the Miami CBD. Implemented: March 1976.
REASONS FOR IMPLEMENTATION	Part of a major demonstration project, funded by the Services and Methods Demo. Program, to increase people moving capability in the I95 corridor.
STATUS	Length: 12.1 km (in and out) No of lanes: 6 - 10 Hours of Operation: 07:00 - 09:00 and 16:00 - 18:00 Construction: Median shoulder removed, no separation.
ASSOCIATED MEASURES	Major Park-and-Ride lot (1200 spaces) and bus terminal at Golden Glades interchange. Exclusive ramp to above lot. New express buses (30 purchased) and routing. Carpool matching program.
ORGANIZATIONS INVOLVED	US DOT, Florida DOT, Metro Dade County Traffic Dept. Transit Depts.
COST	Capital: $23 million Operating: $461 000/yr (1980)
TRAVEL TIME SAVINGS	a.m. peak: Bus: 1 min/Carpools 3 min p.m. peak: Bus: 3 min/Carpools 3 min
TRAFFIC VOLUMES	May 1977 a.m. peak 2 h 1245 Carpools (2+) and 703 violators in HOV lane. Daily bus ridership: 1707 passengers
ACCIDENTS	Disabled vehicles park in HOV lane causing 5 fatalities in last few years.
ENFORCEMENT & VIOLATIONS	Initially for 3-person carpools: Violation rate: 65%. Now for 2-person carpools: Violation rate: up to 30%.
PUBLIC REACTION	Extensive public surveys carried out. Carpoolers cited 'cost' as factor in choice of mode. Up to 33% all drivers opposed to lanes.
FUTURE PLANS	Currently a 48.3 km northward extension is under design - opening date 1985. Existing lanes will be restriped and reduced to 3.3 m in order to provide a median shoulder of 1.8 - 2.4 m.
COMMENTS	Hours of operation were reduced from 6 to 4 h total, lane qualification from 3 to 2. In a.m. peak only 40% eligible carpools used lane. During 3-person qualification: in a.m. peak 2 h only 211 carpools used lane. The major reason for the planned 48.3 km extension is that federal funding for HOV projects is available.

LOCATION	Miami, Florida I95 Cont'd
REFERENCE	Telephone conversation with Gary Price, Road Operations (Tel. 904-488-4284) and Emmet Owens, Surface Transit (Tel. 904-488-7774) both with Florida DOT, Tallahassee 'Evaluation of the I95 Express Bus and HOV Priority Systems' Sept 1978 US DOT.

LOCATION	Los Angeles, California Santa Monica Freeway
DESCRIPTION	Concurrent-flow reserved lane (existing left lane) for buses and carpools (3 persons or more). Freeway is major commuter facility from Santa Monica to Los Angeles CBD. Implemented: March 1976 Cancelled: Aug. 1976
REASONS FOR IMPLEMENTATION	In 1972, the City recommended this project as an alternative to rapid transit. In 1975, it was adopted as a project under the 'Services and Methods Program'.
STATUS	Length: 20.3 km (in) 20.3 km (out) No of lanes: 10 Hours of Operation: 06:30 - 09:30 and 15:00 - 19:00 Construction: utilized existing lane, no separation
ASSOCIATED MEASURES	Ramp meters (30) and Bypass lanes (12) Three Park-and-Ride lots (820 spaces) New bus routes. Carpool matching program 'Commuter Computer'.
ORGANIZATIONS INVOLVED	US DOT, City of Santa Monica Caltrans
COST	Capital: $170 000 Operating: $2.9 million (nb: marketing: $360 000)
TRAVEL TIME SAVINGS	Ramp metering alone reduced travel time by / min Following this, the HOV lane saved 1 min and travel time in the regular lane increased from 5 - 9 min
TRAFFIC VOLUMES	Total no. of carpools in 7 h before: 3479 after 5749 Daily bus ridership before: 1200 after 3800
ACCIDENTS	25/week compared with 10/week previously.
ENFORCEMENT & VIOLATIONS	Initially 40% reducing to 15% after strict enforcement.
PUBLIC REACTION	Extensive public reaction (86% public against project).
FUTURE PLANS	None.
COMMENTS	The project was abandoned after severe public criticism. It was concluded that metered-ramp bypass lanes were safer, acceptable to the public and offered greater time savings than reserved lanes of this nature. In addition, ramp meters improved traffic flow generally.
REFERENCE	'Santa Monica Freeway Diamond Lanes: Vol.11 Technical Report: Sept 1977' US DOT.

LOCATION	Boston, Massachusetts South East Expressway
DESCRIPTION	Concurrent-flow reserved lane for buses and carpools (3 or more persons). One lane in one direction. Existing lane. Implemented: May 1977; Cancelled: Nov. 1977
REASONS FOR IMPLEMENTATION	Converted from Contra-flow operation. The objective being to increase vehicle occupancy before major bridge reconstruction.
STATUS	Length: 13.5 km No of lanes: 8 Hr of Operation: 06:30 - 09:30 Construction: separated by posts; access at beginning only
ASSOCIATED MEASURES	Expansion of 7 existing fringe parking lots and construction of 2 new ones. Carpool matching program (Masspool).
ORGANIZATIONS INVOLVED	Massachusetts Dept. of Public Works
COST	Capital: $92 000 (includ. $40 000 publicity) Operating: $3750/week
TRAVEL TIME SAVINGS	Bus/Carpool: 6 min, Auto: 6 min (Voluntary enforcement) Bus/Carpool: 10 min, Auto:-10 min (Strict enforcement)
TRAFFIC VOLUMES	Oct. 1977 Peak 3 h Carpools (3 or more): all lanes: 1166 Bus passengers : all lanes: 3600
ACCIDENTS	Some increase but still within acceptable limits.
ENFORCEMENT & VIOLATIONS	Violations: 80% (voluntary enforcement); 35% (strict enforcement)
PUBLIC REACTION	Substantial opposition during strict enforcement. This phase only lasted 2 weeks.
FUTURE PLANS	Project cancelled due to public opposition after 2 weeks of strict enforcement. Possibility of a 'separate right-of-way' facility in future.
COMMENTS	Carpools (3 or more) increased by 485 (in 3 h) from March 1977 of which 225 were newly formed. Bus passengers increased by 200. Total number of vehicles in HOV lane = 1630 Estimated savings (1970): Time: $4340 Recovery time from breakdowns and accidents increased considerably due to lack of shoulder.
REFERENCE	'South East Expressway for Buses and Carpools,' Transportation Research Record, TRR 663, 1978.

Appendix D

Separate Rights-of-Way Projects

Data Sheets

LOCATION	Washington, D. C. Shirley Highway (1395)
DESCRIPTION	Separate Right-of-Way facility (2-lane-reversible) for buses and carpools (4 or more) running north-west to Washington. Implemented: Buses: 1969 Buses and Carpools: 1973
REASONS FOR IMPLEMENTATION	It was intended to widen the highway and a study of utilization of the extra lanes as a busway indicated the project was feasible.
STATUS	Length: 17.7 km No of lanes: 6 (general); 2 (HOV lanes) Hours of Operation: 23:00 - 11:00 and 13:00 - 20:00 (wkdys) Construction: separated by concrete barriers; Two shoulders (3 m)
ASSOCIATED MEASURES	Approx. 12 Park-and-Ride lots beyond terminus of HOV lane. Preferential downtown lanes. Exclusive ramps at interchanges for buses and carpools. Carpool matching and vanpool program.
ORGANIZATIONS INVOLVED	Virginia Dept. Highways & Transportation, Washington Council of Governments, WMATA, US DOT.
COST	Capital: $43 million Operating: $220 000/yr (1980)
TRAVEL TIME SAVINGS	Typical: 15-20 min
TRAFFIC VOLUMES	a.m. peak hour: 28/6 carpools; 250 buses (HOV lanes) 6600 vehicles (general lanes)
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Violations 3%. Random enforcement.
PUBLIC REACTION	Surveys have indicated that 25% carpools formed because of HOV lanes). Currently some pressure to lower lane qualification.
FUTURE PLANS	Intend installing freeway surveillance and control over this section including 19 metered ramps (no bypass lanes) at a cost of $15 million. Completion date 1983.
COMMENTS	Approx. 98% of HOV traffic uses the facility from 06:00 to 09:30. During the remaining hours of operation in the peak direction, the usage is practically non-existant. It may be possible to use changeable message signs to lower the lane qualification when the HOV lanes have minimal use. A 4-lane facility (I66) is under construction (16.1 km) which will only allow 4-person carpools and buses in peak h. (completion: May 82)

LOCATION	Washington, D. C. Shirley Highway (1395) Cont'd
REFERENCE	'Evaluating Alternative Traffic Operations for the Commuter Lanes in the Shirley Highway' July 1977, US DOT Telephone conversation with R.W. Jeffrey, Asst. Transportation Planning Engineer, Virginia DOT. Richmond, Jan. 1981 (Tel. 804-786-7352)

LOCATION	Los Angeles, Cal. San Bernadino Freeway
DESCRIPTION	Separate right-of-way facility (2 lane, 2 way) for buses and carpools (3 or more persons) connecting major Park-and-Ride facility at El Monte to downtown Los Angeles. Implemented: Buses & Carpools, June 1977
REASONS FOR IMPLEMENTATION	Initial investigation for busway (1970). State Bill in 1976 allowed carpools on buslanes where feasible.
STATUS	Length: 17.7 km No. of Lanes: 8 (general); 2 (HOV lanes) Hours of operation: 06:00 - 10:00 and 15:00 - 19:00 (carpools) 24 h, 7 d/week (buses) Construction: separated by both concrete barriers and a 4 m shoulder with pylons.
ASSOCIATED MEASURES	Three off-line bus stations with parking. Over 10 Park-and-Ride/fringe parking lots east of facility. Carpool matching, vanpool program/Downtown reserved lanes. Exclusive ramps at interchanges/Major transit improvements. (new buses & re-routing)
ORGANIZATIONS INVOLVED	Caltrans, S. California Regional Transit District, City & County of Los Angeles, City of El Monte, Southern California Association of Governments, US DOT
COST	Capital: $57.0 million Operating: Unknown
TRAVEL TIME SAVINGS	Typical: 17 min a.m. peak; 8 min p.m. peak; (greater during incidents)
TRAFFIC VOLUMES	a.m. peak: 4 h: 2200 carpools; 200 buses p.m. peak 4 h: 2150 carpools; 200 buses
ACCIDENTS	No significant increase in accidents since carpools introduced.
ENFORCEMENT & VIOLATIONS	Violation rate less than 10%. Highway patrol expends 9 h per week on facility in addition to normal duties.
PUBLIC REACTION	Very good. Surveys in 1977 indicated that 50% of users would not rideshare if not for busway.
FUTURE PLANS	1.6 km extension west to Union Station in design stage completion 1984. A further 69.2 km of separate right-of-way facilities are planned over the next 7 years in the area.
COMMENTS	The peak hour is 06:45 - 07:45 (1100 carpools 100 buses) The facility is thus approaching capacity which is regarded as 1400 - 1600 vehicles/h to maintain 88.5 km/h. The extremely long congestion period of 7 hours has probably led to Los Angeles being in the forefront of freeway management techniques.

LOCATION	Los Angeles, Cal. San Bernadino Freeway Cont'd
REFERENCE	'San Bernadino Freeway Expressway Busway Evaluation of Mixed Mode Operation' July 1978 US DOT Telephone conversation with C. O'Connell, Traffic Operations Caltrans, Los Angeles (Tel. 213-620-5138)

LOCATION	Pittsburgh, Pennsylvania South Busway
DESCRIPTION	Separate right-of-way facility for buses (shared with streetcars in one section) from CBD to southern residential areas. Implemented: Dec. 1977
REASONS FOR IMPLEMENTATION	Extreme congestion for buses in existing tunnel to southern residential area. Existing streetcar tunnel was rehabilitated for the joint use of streetcars and buses and a 3.2 km extension added for buses only.
STATUS	Length: 6.4 km No. of lanes: 2 Hours of Operation: 24 h Construction: independent right-of-way partially shared with streetcars.
ASSOCIATED MEASURES	Three exclusive ramps for buses only. Four Park-and-Ride areas at Southern end (all in shopping plazas).
ORGANIZATIONS INVOLVED	Port Authority of Allegheny County, State of Pennsylvania US DOT
COST	Capital: $27 million
TRAVEL TIME SAVINGS	From 25 min to 2.5 h depending on weather conditions and general congestion levels.
TRAFFIC VOLUMES	Approx. 10 000 passengers into downtown each a.m. and out of downtown each p.m. (May 1979).
ACCIDENTS	One major accident only between a streetcar and a bus.
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	Well received by public.
FUTURE PLANS	The new LRT line will share the South Busway and also include a further 9.6 km in its own right-of-way.
COMMENTS	The project was 80% funded by the US DOT. Any construction projects are extremely expensive due to topography. An East Busway is currently under construction at a cost of $115 million for 11.3 km. Completion date: 1982
REFERENCE	'Busway to the Golden Triangle' Spring 1979, Bus World Magazine Telephone conversation with T. Olup, Construction and Development Dept., Port Authority of Allegheny County, Dec. 1980 (Tel. 412-237-7373)

Appendix E

Metered-Ramp Bypass Lanes

Data Sheets

LOCATION	Los Angeles, California Various Freeways
DESCRIPTION	Bus only metered-ramp bypass lanes (8) and bus/carpool (2 or more) metered-ramp bypass lanes (150) Installed in period 1970 - 1981
REASONS FOR IMPLEMENTATION	Regarded as an inexpensive ridesharing incentive. Criteria for implementation include existing & potential HOV use, potential for nearby HOV parking lots and the most important - the ability to implement without expensive construction costs.
STATUS	No. of metered ramps (Los Angeles area): 520 No. of bypass lanes: 8 bus only; 150 bus/carpool Hours of Operation: a.m. or p.m. peak (sometimes both periods)
ASSOCIATED MEASURES	Carpool matching program, vanpool program. Park-and-Ride lots fringe parking lots (Total over 40 lots in area) preferential downtown parking; Exclusive lanes (San Bernadino HOV lanes); Major public participation program ongoing to reach agreement on transportation plans in area.
ORGANIZATIONS INVOLVED	Caltrans
COST	Typical cost: $10 000
TRAVEL TIME SAVINGS	1.5 min average
TRAFFIC VOLUMES	Min ramp use: 50 - 350 HOV/h
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Over 30% violation rate.
PUBLIC REACTION	Generally well accepted.
FUTURE PLANS	1981: 140 ramp meters; 50 metered-ramp bypass lanes 1981 - 1986: 400 ramp meters; 140 metered-ramp bypass lanes
COMMENTS	Metered-ramp bypass lanes regarded as one small part of major ridesharing incentives; Caltrans intends to centralize control of ramp meters. In addition bus/carpool lanes are planned for the following facilities: San Bernadino, 1.6 km extension (1984); Harbour Freeway, 12.9 km (1987); Century Freeway, 27.3 km (1988); Santa Ana Fwy, 28.2 km (1988); Very heavy congestion: 3 h a.m. peak, 4 h p.m. peak

LOCATION	Los Angeles, California Various Freeways Cont'd
REFERENCE	Telephone conversation with Chuck O'Connell, Chief, Traffic Operations, Caltrans Los Angeles Jan. 1981 (Tel. 213-620-5138)

LOCATION	Milwaukee, Wisconsin East West Freeway
DESCRIPTION	An exclusive ramp for buses only which bypasses an existing metered ramp (outbound). Constructed: 1975
REASONS FOR IMPLEMENTATION	Several express bus routes from city converge on this ramp.
STATUS	No. of metered ramps (E.W. Freeway) 12; No. of bypass lanes: 1 Hours of operation: 15:30 - 17:30 (meters) 24 h (exclusive ramp)
ASSOCIATED MEASURES	Park-and-Ride lots.
ORGANIZATIONS INVOLVED	Wisconsin Division of Highways
COST	Minimal.
TRAVEL TIME SAVINGS	2-3 min typical (short queues)
TRAFFIC VOLUMES	30 buses in peak period.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	1-2 violators/d
PUBLIC REACTION	None.
FUTURE PLANS	None.
COMMENTS	Bus only metered-ramp bypass lanes on I43 (1) and I94 (1) also. No plans for future ramp meters as City of Milwaukee regards them as discriminatory. Unable to install bus/carpool metered-ramp bypass lanes because State has no authority to give preferential treatment to carpools. Peak hour congestion minimal compared with Los Angeles.
REFERENCE	Telephone conversation with Ron Sonntag, Freeway Ops. Supervisor Wisconsin Division of Highways Dec. 1980 (Tel. 214-670-4025)

LOCATION	Milwaukee, Wisconsin I43
DESCRIPTION	Bus only metered-ramp bypass lane (outbound) at North Ave. This lane is also metered but vehicle detectors give preferential metering rate. Installed: 1978
REASONS FOR IMPLEMENTATION	Several express bus routes from city converge on this ramp.
STATUS	No. of metered ramps (I43): 7 No. of bypass lanes: 1 Hours of Operation: 16:15 - 17:30
ASSOCIATED MEASURES	Park-and-Ride Lots.
ORGANIZATIONS INVOLVED	Wisconsin Division of Highways
COST	Minimal.
TRAVEL TIME SAVINGS	2-3 min
TRAFFIC VOLUMES	20 - 25 buses in peak period.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	None.
FUTURE PLANS	None.
COMMENTS	Bus only metered-ramp bypass lanes on East West Freeway (1) and I94 (1) also For further comments, see 'East-West Freeway'
REFERENCE	See 'East-West Freeway'.

LOCATION	Milwaukee, Wisconsin: I94
DESCRIPTION	Bus only metered-ramp bypass lane (inbound) at Holt Ave. This lane is metered but vehicle detectors give preferential metering rate. Installed: 1978
REASONS FOR IMPLEMENTATION	Substantial use of ramp by express buses operating from nearby Park-and-Ride lot.
STATUS	No. of metered ramps: (I94): 2; No. of bypass lanes: 1 Hours of Operation: 07:00 - 09:00
ASSOCIATED MEASURES	Park-and-Ride Lots.
ORGANIZATIONS INVOLVED	Wisconsin Division of Highways
COST	Minimal.
TRAVEL TIME SAVINGS	2-3 min
TRAFFIC VOLUMES	Approx. 20 buses in peak hours.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Minimal violations.
PUBLIC REACTION	None.
FUTURE PLANS	None.
COMMENTS	Bus only metered-ramp bypass lanes on East West Freeway (1) and I43 also. For further comments see 'East-West Freeway'.
REFERENCE	See 'East-West Freeway'.

LOCATION	Minneapolis, Minnesota: I35W
DESCRIPTION	Initial bus only metered-ramp bypass lanes installed in 1975; At this time there are 7 bus only bypass lanes (inbound) and 4 bus/carpool (3 or more) lanes (2 inbound, 2 outbound).
REASONS FOR IMPLEMENTATION	Installed initially as part of a major TSM strategy on 135W (Services & Methods Demonstration Program)
STATUS	No. of metered ramps (I35W): 54, No. of bypass lanes: 11 Hours of Operation: 06:00 - 09:00 (inbound) 15:00 - 18:00 (outbound)
ASSOCIATED MEASURES	Park-and-Ride Lots. Surveillance and Control. Major transit improvements (I35W Flyers). Carpool matching program.
ORGANIZATIONS INVOLVED	City of Minneapolis Minnesota Dept. of Highways
COST	$50 000 each
TRAVEL TIME SAVINGS	Typical 2-6 min., occasionally 10 min, if extensive queuing.
TRAFFIC VOLUMES	Inbound: 8-10 buses in peak hours. Outbound: Up to 120 buses and 90 carpools in peak hours.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Minimal on bus - only bypass ramps. Varies from 20% - 50% on bus/carpool bypass ramps.
PUBLIC REACTION	Generally very supportive but some pressure to open bus only bypass ramps to carpools.
FUTURE PLANS	None for I35W. Intend to install freeway surveillance control including ramp metering on 24 km, I94. In addition two bus/carpool bypass ramps planned (1982) and two in 1984.
COMMENTS	In 1975, 8 bypass lanes were for buses only and one bypass lane was for buses and carpools. In 1978 one bus bypass lane was converted to allow carpools and a further three were constructed. The minimum no. of buses for installation is from 4-10 in peak period. Bus passengers have increased from 3000/d (1975) to 13000/d (1980)
REFERENCE	Telephone conversation with Glen Carlson, Traffic Management Centre, Minnesota Dept. of Highways, Dec. 1980 (Tel. 612-341-7500)

LOCATION	San Francisco, California: Route 101 and Route 280
DESCRIPTION	Bus/carpool metered-ramp bypass lanes Route 280 at Wolf Rd, 1976 (2 or more) and Route 101 at Guadalupe, 1980 (3 or more)
REASONS FOR IMPLEMENTATION	Regarded as inexpensive ridesharing incentive
STATUS	No. of metered ramps (region): 60 No. of bypass lanes: Route 280: 1; Route 101: 1 Hours of Operation: a.m. peak
ASSOCIATED MEASURES	Carpool matching program, vanpool program (RIDES). Park-and-Ride lots, fringe parking lots (Total: 22 in area) Downtown preferential parking. Exclusive lanes; Routes 101 (6.4 km), 280 (3.2 km), 58 (5.6 km). Toll plaza preference for HOV (Oakland Bay Bridge); Flexible hours demonstration project.
ORGANIZATIONS INVOLVED	Caltrans
COST	Route 280: Minimal (re-striping); Route 101: $15 000
TRAVEL TIME SAVINGS	Route 280: Up to 1.5 min Route 101: Up to 5-10 min (key bottleneck)
TRAFFIC VOLUMES	Route 280: 80 carpools/2 buses in peak hour Route 101: 100 carpools and buses in peak hour
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Violations less than 10%. Not regarded as a problem. No specific enforcement.
PUBLIC REACTION	None.
FUTURE PLANS	1981 - 1986: Intend to install further 30-40 ramp meters and 10-15 bypass lanes in area.
COMMENTS	Intend extending Route 580 exclusive lanes by 9.6 km west (1983) and Route 101 exclusive lanes north by 6.4 km (1984) and also Route 580 approach to Bay Bridge (1985) Metered-ramp bypass lanes regarded as one small part of a number of ridesharing incentives. Congestion period: 1.5 h (a.m.) 1.5 h (p.m.)
REFERENCE	Telephone conversation with L. Newman, Chief Traffic Operations, Caltrans, San Francisco, Jan 1981 (Tel. 415-557-2342)

LOCATION	Dallas, Texas: North Central Expressway (US 75)
DESCRIPTION	Bus only metered-ramp bypass lane (inbound), 6.4 km from CBD Installed: 1976
REASONS FOR IMPLEMENTATION	Congestion at ramp caused buses to be trapped in queue.
STATUS	No. of metered ramps: 39; No. of bypass ramps: 1 Hours of Operation: 07:00 - 09:00 16:00 - 18:00
ASSOCIATED MEASURES	Carpool matching program 'Double Up For Dallas' 1 Park-and-Ride Lot approx. 16 km from CBD on US 75. Some additional buses placed on existing routes.
ORGANIZATIONS INVOLVED	City of Dallas Texas Highway Dept.
COST	$5000
TRAVEL TIME SAVINGS	3 min (a.m.). No problem in p.m. peak
TRAFFIC VOLUMES	15 buses in a.m. peak. No increase in transit use.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Violation rate up to 20%. Selective enforcement only.
PUBLIC REACTION	None.
FUTURE PLANS	None. Dallas has very low vehicle occupancy rate and has no areas of high density.
COMMENTS	Vehicle occupancy rate going down. Carpool matching program is not very successful and transit ridership is low. Hence, there appears to be minimal opportunity for implementation of preferential treatment measures for HOV. US 75 is the only metered freeway in Dallas.
REFERENCE	Telephone conversation with Sam Wilson, Traffic Ops. City of Dallas, Dec. 1980 (Tel. 214-670-4538)

LOCATION	Houston, Texas: South West Freeway (US 59)
DESCRIPTION	Bus (& vanpool) metered-ramp bypass lanes (2 No.). Installed: 1978
REASONS FOR IMPLEMENTATION	In response to requests from transit authority who wished to alleviate congestion for buses on ramp. Buses were originating from nearby Park-and-Ride lots.
STATUS	No. of metered ramps (US 59): 18; No. of bypass ramps: 2 Hours of Operation: a.m. & p.m. h
ASSOCIATED MEASURES	Private vanpool program. Park-and-Ride Lots. Carpool matching program.
ORGANIZATIONS INVOLVED	Texas Highway Dept. City of Houston, Metropolitan Transit Authority
COST	$15 000 each
TRAVEL TIME SAVINGS	8-12 min (very long queues).
TRAFFIC VOLUMES	12-25 buses/vanpools in peak hours.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	No specific enforcement. Very high violation rate (70%).
PUBLIC REACTION	None.
FUTURE PLANS	No intent to install metered-ramp bypass lanes but intend to install a total of 65 ramp meters on Houston freeways in 1981.
COMMENTS	Other freeways with metered ramps: North Freeway (18) East Tex. Freeway (20) The Houston North Freeway has also a contra-flow lane for buses and vanpools with associated Park-and-Ride Lots. (3 lots with 2400 spaces)
REFERENCE	Telephone conversations with Texas Highway Dept. Officials Dec. 1980 Larry Galloway: Freeway Traffic Management (713-869-4571) Herman Haenal : Freeway Oper. Management (512-452-8141)

LOCATION	San Diego, California — Various Freeways
DESCRIPTION	Bus/carpool (2 or more) metered-ramp bypass lanes on Route 163 (1), 1979; Route 94 (7), 1978 and Route 8 (4), 1981. All bypass lanes independently metered.
REASONS FOR IMPLEMENTATION	Regarded as inexpensive ridesharing incentive. Criteria for implementation includes: cost, transit use, carpooling promotion. No specific criteria.
STATUS	Route 63: Ramp Meters 1, Bypass Lanes 1, Inbound 1, Outbound - Route 94: Ramp Meters 23, Bypass Lanes 7, Inbound 7, Outbound - Route 8: Ramp Meters 15, Bypass Lanes 4, Inbound 3, Outbound 1
ASSOCIATED MEASURES	Park-and-Ride lots, fringe parking lots (Total 25 lots). Carpool matching program, vanpool program. Toll plaza preference for HOV. Downtown preferential parking. Exclusive lane (Route 163, length 0.8 km).
ORGANIZATIONS INVOLVED	Caltrans
COST	Typical $30 - $40 000 (only 50% installations required new construction)
TRAVEL TIME SAVINGS	From 0 - 5 min
TRAFFIC VOLUMES	In peak period 16% traffic are vehicles with more than one person. There has been no measurable increase in HOV due to bypass lanes.
ACCIDENTS	Minimal.
ENFORCEMENT & VIOLATIONS	Viclations less than 15%.
PUBLIC REACTION	Good acceptance.
FUTURE PLANS	1981: Ramp Meters 6, Bypass Lanes 1 1981 - 1986: Ramp Meters 75, Bypass Lanes 20 (Total installations)
COMMENTS	Three of the above bypass lanes are on freeway-freeway connectors. Metered-ramp bypass lanes regarded as one small part of a whole range of ridesharing measures. Studies underway for exclusive bus/carpool lanes (2-lane reversible) on I-15 from Route 163 to Poway Rd. Construction anticipated in 1986 Congestion period: 1 h (a.m.) 1 1/2 h (p.m.)
REFERENCE	Telephone conversation with Mr. Harvey, Chief, Traffic Systems Branch, Caltrans, San Diego (Tel. 714-237-6895)

LOCATION	Portland, Oregon I-5
DESCRIPTION	Sixteen bus/carpool (2 or more) metered-ramp bypass lanes plus sixteen associated ramp meters currently under construction.
REASONS FOR IMPLEMENTATION	This freeway is regarded as the most congested in Oregon. Studies showed that ramp metering and bypass lanes would yield substantial time and energy savings at minimal cost.
STATUS	No ramps are metered in Portland at this time. Planned no. of metered ramps and bypass lanes (1981):16 Hours of Operation: 06:30 - 09:30 and 15:30 - 18:30
ASSOCIATED MEASURES	Carpool Matching. Park-and-Ride and Carpool Parking Lots (Total of 50 lots in Portland Area. average no. spaces: 50-60). Exclusive lanes on Banfield Expressway
ORGANIZATIONS INVOLVED	Oregon Dept. of Transport City of Portland
COST	Total Cost $500 000 (i.e., $33 500/ramp)
TRAVEL TIME SAVINGS	Estimated travel time savings over whole metered length are 15 min due to meters. (Original time 21 min)
TRAFFIC VOLUMES	Not applicable
ACCIDENTS	Not applicable
ENFORCEMENT & VIOLATIONS	Not applicable
PUBLIC REACTION	Promotional campaign to public during design stage.
FUTURE PLANS	1982-83 A further 8 ramp meters and 8 associated bypass lanes planned on I-5, south of Portland
COMMENTS	Substantial benefits estimated due to ramp metering alone. Installations are on all ramps within congested freeway section. Time savings are estimated as above and energy savings due to lack of congestion calculated at 27%.
REFERENCE	Telephone conversation with E. Mershon, Project Management Branch Oregon Dept. of Transport, Portland, Dec. 1980 (Tel. 503-238-8226)

LOCATION	Sacramento, California: Route 50
DESCRIPTION	One bus only and three bus/carpool (2 or more) metered-ramp bypass lanes (all inbound) plus 9 ramp meters currently in design stage. Anticipated installation date: May 1982
REASONS FOR IMPLEMENTATION	The recommendations of a feasibility study to alleviate congestion on Route 50. Exclusive HOV lanes and highway widening were also investigated and rejected.
STATUS	No. ramps are metered at this time. Planned no. of metered ramps (1982): 9 Hours of Operation: Probably 2 h in a.m. peak Planned no. of bypass lanes (1982) : 4
ASSOCIATED MEASURES	Carpool Matching and Transit Info. Program, vanpool program. Flexible work hour assistance to employers. Parking management assistance to employers. Three fringe parking lots on Route 50 (Total of 22 lots in area).
ORGANIZATIONS INVOLVED	Caltrans
COST	$22 000 - $75 000/ramp
TRAVEL TIME SAVINGS	Unknown.
TRAFFIC VOLUMES	Current total ramp use: 800 veh/h (25% HOV)
ACCIDENTS	N/A
ENFORCEMENT & VIOLATIONS	N/A
PUBLIC REACTION	The general public were involved in the planning stages of the project. No significant opposition.
FUTURE PLANS	N/A
COMMENTS	There are currently no exclusive lanes for HOV in Sacramento, although there are over 22 carpool parking lots in the area. A recent study of I-80 rejected HOV lanes and ramp metering and recommended a Light Rail Transit System in 1985. The peak period in Sacramento lasts 50 min.
REFERENCE	Telephone conversation with Jim Standlee, Transportation Planning Branch, Caltrans, Jan. 1981 (Tel. 916-674-4484)

LOCATION	San Francisco, Cal. Route 580 (Alameda County)
DESCRIPTION	Concurrent-flow lanes for buses and carpools (3 or more persons) on Route 580, approx. 32.2 km east of the Oakland Bay Bridge (between I680 and Route 238) Implemented: Dec. 1977
REASONS FOR IMPLEMENTATION	Part of the construction of the new Interstate 580. Hence implemented on opening of freeway.
STATUS	Length: 5.6 km No of lanes: Hours of Operation: 06:00 - 18:00 Construction: Separated by 2.4 m common shoulder and pylons
ASSOCIATED MEASURES	No Park-and-Ride facilities adjacent to Route 580 but 22 lots in San Francisco area. Carpool matching and vanpool program. Downtown preferential parking. Flexible hours demonstration project.
ORGANIZATIONS INVOLVED	Caltrans
COST	Capital: viewed as part of the new construction cost of the freeway ($60 million) Operating: Unknown
TRAVEL TIME SAVINGS	a.m. and p.m. peak: 1 min
TRAFFIC VOLUMES	a.m. peak hour: 130 carpools, 7 buses, 60 violators (HOV lane) p.m. peak hour: 140 carpools, 9 buses, 70 violators
ACCIDENTS	Accident rate declined since construction of new freeway with improved alignment.
ENFORCEMENT & VIOLATIONS	Approx. 30% violations. No special patrols.
PUBLIC REACTION	Strong pressure to lower the carpool qualification.
FUTURE PLANS	A 9.6 km westerly extension is under construction (completion in 1983). The 3.2 km approach to the Oakland Bay Bridge is under study for HOV lanes.
COMMENTS	Due to public pressure, a study has been initiated to determine the best method of operating the current facility and the west extension (e.g., to determine whether the carpool qualification should be lowered).
REFERENCE	'Ridesharing Facilities and Services' March 1979, Caltrans Telephone conversation with L. Newman, Traffic Operators Caltrans, San Francisco. Jan. 1981 (Tel. 415-557-2342)